THE TECHNIC OF ORAL RADIOGRAPHY

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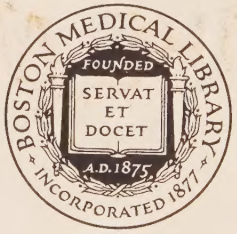

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THE TECHNIC
OF
ORAL RADIOGRAPHY

BY

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ST. LOUIS, MO.

WITH ONE HUNDRED SIXTY-FIVE ILLUSTRATIONS

SECOND EDITION

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TO

DOCTOR C. EDMUND KELLS

THE FIRST RADIODONTIST AND A MARTYR TO
THE DEVELOPMENT OF RADIODONTIA

IN APPRECIATION OF HIS VALUED FRIENDSHIP,
STIMULATING CRITICISM, PROFESSIONAL IDEALS,
AND PERENNIAL YOUTH, THIS BOOK IS
AFFECTIONATELY DEDICATED.

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PREFACE TO SECOND EDITION

The gratifying reception accorded the first edition demonstrated the need and desire for systematic procedure in oral radiography. The changes and additions are principally features which have been established by further observation and tests, or statements to render the instructions more explicit.

Some reviews of the book suggested that many operators might not carefully apply the details described. However, to operate systematically is no more laborious than to operate carelessly, and the results are infinitely more effective. For a radiodontic examination, the subject must be posed in some manner, the film packet must be placed in some location, and the cone must be directed toward the subject. Why not pose the subject in a definite position, place the film packet to precisely cover the region, and direct the cone at a specific angle which by the law of averages offers the most favorable prospect of registering true images? Also chemical processes must be performed to disclose the images. Why not employ a system which will produce uniform results, and reveal the most information? The answer appears obvious, and an earnest effort has been made to clearly describe the details on the following pages.

CLARENCE O. SIMPSON.

St. Louis.

PREFACE TO FIRST EDITION

No branch of dental practice has received so little technical consideration as radiodontia. The importance and application of radiodontic examinations have been extolled, and volumes have been written on the interpretation of dental radiographs, but the technical phases of the science have been left to individual ingenuity.

Only recently have dental colleges begun to include radiodontia in their curricula, and x-ray physics are usually the principal feature of the courses. Consequently dentists have attempted to practice radiodontia with only the instruction from salesmen in the manipulation of the machine. The advertising propaganda to sell radiographic equipment has created the impression that skill or knowledge is not required for radiography, and has deterred operators from adequate preparation or subsequent training.

The purpose of this book is to present a systematic technic for practical instruction in dental schools, and for the guidance of dental practitioners that they with the least difficulty may obtain the most service from radiography. The instructions for the examination of each region are concisely listed opposite the illustrations for convenient reference. Following this in the explanatory description is a discussion of the details with radiographic specimens for a comprehensive theory of the regional examination. Repetition and superfluous description have been avoided, hoping that the student would carefully peruse the text instead of trying to adopt the technic from the illustrations and directions. The system was evolved from the author's attempts to produce uniform radiographs in registering the progress and results of canal operations. The advantages of the system observed in radiodontic examinations for other purposes, and later in a practice limited to radiodontia prompts this detailed description for the aid of others.

The author welcomes this opportunity to publicly express his gratitude for special assistance in the preparation of the book, to Dr. Howard R. Raper for his consistent inspiration and counsel and to Dr. Erwin Henselmeier for his intelligent cooperation in posing for the illustrations.

CLARENCE O. SIMPSON.

St. Louis.

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TECHNIC OF ORAL RADIOGRAPHY

INTRODUCTION

In the otherwise excellent textbooks on oral radiography, comparatively little space has been devoted to the operative technic and the detail so essential to proficiency in technical procedure. As evidence of the slight consideration given to systematic methods in radiodontic examinations, attention is directed to the haphazard technic and mediocre results generally prevailing after more than twenty-five years during which radiography has been used in oral diagnosis. Contributors to periodic literature have occasionally proclaimed a "standardized" technic dealing with generalities, or featuring a complicated system of calculation and intricate appliances, none of which has had sufficient appeal to be extensively adopted.

A sloth said, "Technic is the art of doing a simple act with the utmost difficulty," but since oral radiography is not simple and an attempt will be made to eliminate the avoidable difficulties, further rebuttal in this instance is unnecessary. The common lack of methodical execution, uniformity in results, and adequate diagnostic data in radiodontic examinations is sufficient motive for expounding technic.

Prerequisites for radiodiagnosis are superior radiographs and a thorough x-ray examination, without which interpretation is hazardous. Uniformly superior radiographs can only be produced by correct methods and attention to detail. A thorough radiographic examination

requires an intimate knowledge of the regional anatomy, a keen discrimination of the physiologic and pathologic factors involved, an appreciation of the limitations encountered, and an acute sense of obligation toward the service. These qualifications are acquired only by professional training and extensive clinical experience, and even this preparation is not infallible.

Laws regarding the practice of dentistry specify that, with limited exceptions for students in dental schools and physicians, dental operations may be performed only by a licensed dentist. The insertion of foreign materials in the mouth of a patient, for the purpose of diagnosis, constitutes the practice of dentistry in the spirit and letter of the definition. The subjection of a patient to the dangers of traumatism, transmission of disease, high voltage electric current, and destructive radiation entails a greater risk than the average dental operation.

In view of the legal and moral restrictions, and the inability of an unqualified operator to make adequate radiodontic examinations, this text is not intended to serve as a manual of instruction for office assistants or laboratory technicians, but to promote a higher standard of radiodontic service by professional practitioners.

The technic to be described was devised by the writer in 1916, when it became evident that system was equally essential in radiographic examinations as other operative procedures, and has proved eminently satisfactory to others who have adopted it. Although simple in principle, an explanation of the important details in obtaining the maximum efficiency with it, requires an extended commentary.

CHAPTER I

EQUIPMENT

Ingenuity, knowledge and skill may achieve wonders with crude tools, and seductive salesmanship is conducive to superfluous equipment, but technical excellence is encouraged by suitable appliances and favorable environment.

When radiographic work is done in connection with other dental operations, it is desirable to have a room exclusively for the x-ray examinations. The advantages of this plan in service, safety, and impression, warrant any reasonable sacrifice in office arrangement and it should be considered before purchasing equipment. The operating room should be large enough for convenience, well lighted and ventilated, accessible to the dark room, and afford protection by distance or construction to office associates and employees.

In view of the present excessive production, and the varied types of apparatus offered for sale, the choice of equipment is usually a perplexing problem. A discussion of the characteristics of the different machines being irrelevant and of temporary value due to frequent changes, the reader is referred to the manufacturer's catalogues for illustrations and description of modern apparatus.

By evolution the static generator, the high frequency coil, and the induction coil have been universally superseded by the interrupterless transformer. The hot cathode tube has now made it possible to dispense with motor

rectification and introduced the small mobile equipment. There are several experienced, reliable manufacturers supplying suitable apparatus for oral radiography, and by consulting one who has different models, the relative merits will be better presented than by a dealer with only one type.

The floor space often influences the selection of radiographic apparatus, as the unit type can be used in a small operating room which would not accommodate a more elaborate outfit. However, when the space is available, a rectifying transformer with a reserve capacity, a convenient tube stand, and overhead transmission of the high voltage current will prove more satisfactory to an earnest practitioner. This installation has the advantages of rectified current for either gas or Coolidge tubes, surplus energy with variable control, every facility in manipulation, and the greatest protection for the operator by permitting the use of a protection screen.

The Transformer.—The capacity of the transformer is of more importance than the type, and one delivering a voltage equivalent to a 5-inch "back up" (commonly called a 5-inch machine), and 40 milliamperes is desirable for oral radiography. This will supply ample power for all requirements, and provide some reserve capacity under usual operating conditions which is a maintenance factor in all machinery. Machines of less capacity are limited to a short target-film distance which gives inferior perspective and definition for diagnostic radiography. A selective control for regulating the current to demand is decidedly preferable to the fixed voltage of some models.

The operation of the transformer is an insignificant phase of radiography, and an "automatic machine" of limited efficiency is an inauspicious preparation for the

intelligent practice of radiodontia. There are frequent indications for changes in voltage and milliamperage in skillful operating, and adequate provisions should be made for such regulation. Foot switches have mechanical limitations, are likely to be accidentally closed, and should not be used except when necessary to enable the operator to keep out of tube range. Circuit breakers and stabilizers which have recently been added to some transformers are useful accessories, but not essential under favorable electrical conditions.

The Tube Stand.—A separate tube stand of appropriate design gives an unlimited range of adjustment, reduces the vibration of the tube during exposure, and obviates the necessity for placing the transformer near the patient. The tube stand is the chief medium of angulation, and certain features of construction determine the utility of it. An inconvenient stand causes unnecessary danger, additional labor, difficult poses, and constant annoyance because of the many changes in position required. To assure facility in operating, one should be familiar with the advantages and limitations of a tube stand before buying it. The requirements of oral radiography have not been considered in designing tube stands, and those which are the most suitable, are rarely recommended for the purpose by dealers.

The stand should be rigid, well balanced, easily moved, and whenever possible have friction adjustments instead of locking devices. All adjustments should be calibrated, the rotary ones in degrees, and the straight in quarter inches, for refinement in technic is attained by accurate calculation—not by guessing.

The tube carrier should have sufficient range of vertical movement to allow of its being raised well above the head of a tall subject when seated, and a horizontal extension which will permit the tube's being passed to the opposite

side of the operating chair. The tube supports should guard the patient from contact with the high tension wires, without any part projecting to interfere with the desired positions.

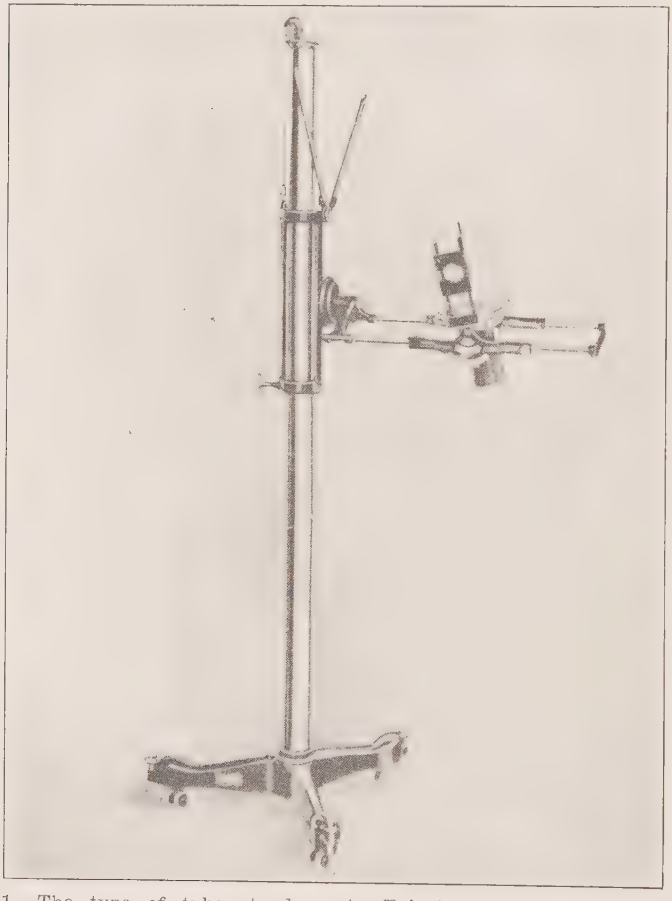


Fig. 1.—The type of tube stand most efficient and convenient for oral radiography.

A stereoscopic shift and centering movement with compensating adjustment for different target-film distances should be included in the construction. The usual arrangement for stereoscopic radiography offers little

convenience for refined technic, in adapting the stereoscopic examination to the principles of binocular vision.

The assortment of cones included in the equipment should consist of at least three of the following general dimensions: One not more than 2½ inches in diameter and sufficiently long to maintain the proper target-film distance, for routine intraoral examinations. Another about 3 inches in diameter and 6 inches shorter than the

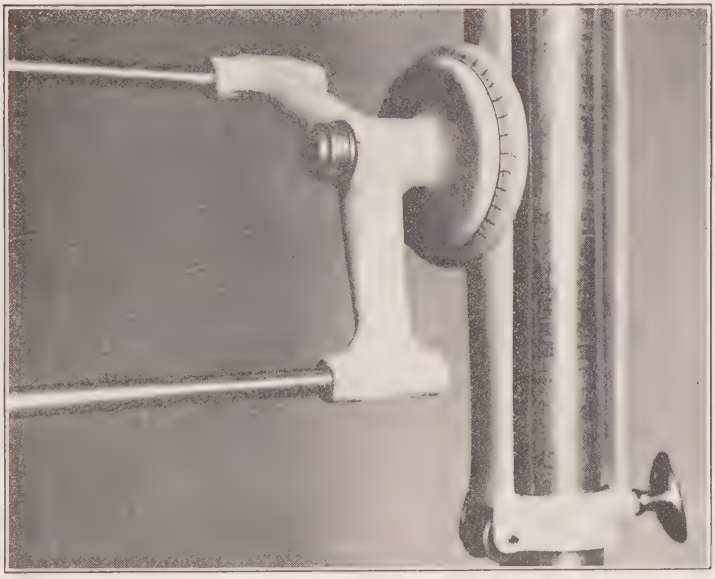


Fig. 2.—The calibration which may be added to the tube stand shown in Fig. 1, to determine the vertico-horizontal angle of the central rays.

first mentioned, for occlusal views and hurried examinations of intractable subjects. A third about 5 inches in diameter and 12 inches long, for extraoral and sinus examinations. The diaphragm opening should be the smallest permissible with the cylinder in use, and a supplemental lead diaphragm may be advantageously used with some cones of incorrect proportions.

With adequate penetration, a filter is not essential for

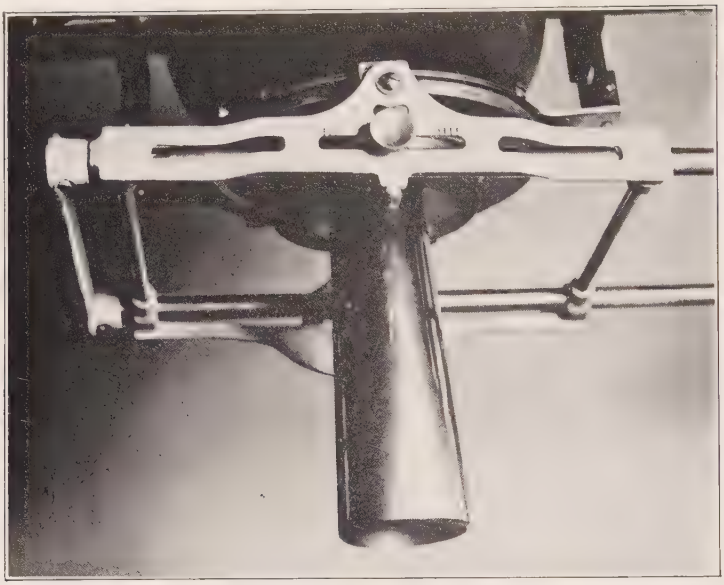


Fig. 3.—Illustrating the calibration which may be added to most tube stands for correction of the stereoscopic shift.

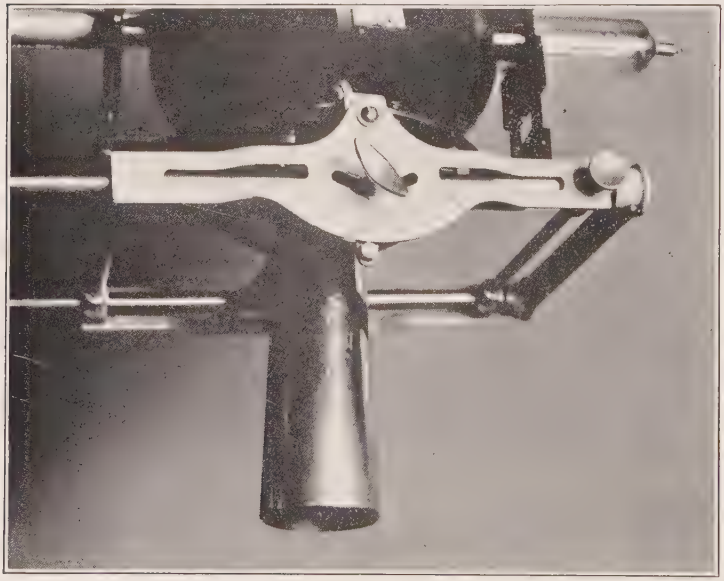


Fig. 4.—The calibration of the tube stand shown in Fig. 1, which may be used to determine the mesio-distal angle of the central rays.

protection of the patient, but a sheet of aluminum no more than ¼ of a millimeter in thickness is useful in absorbing the scattered radiation from the walls of the

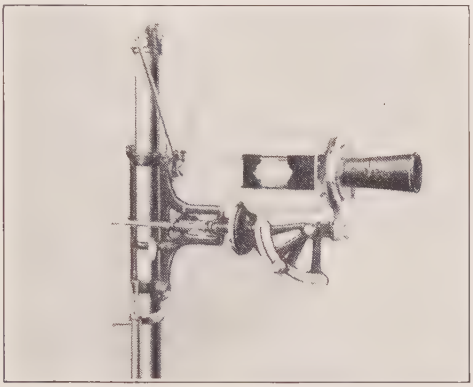


Fig. 5.—A type of tube stand unsuitable for intraoral radiography because of the tube support interfering with some positions. Inverting the tube carrier to avoid this difficulty necessitates reversal of the tube or the polarity.

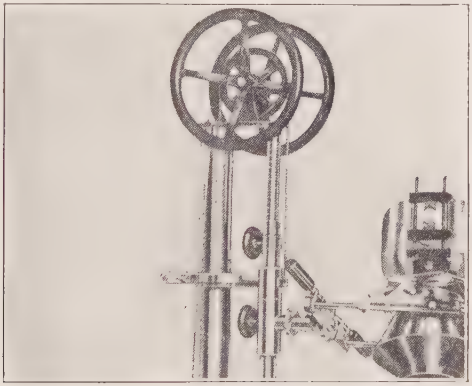


Fig. 6.—A type of tube stand which has superfluous parts at the top likely to interfere with the terminal wires, and is laborious to operate because of the locking devices required to hold the tube in position.

tube and in obstructing the illumination and heat which may arouse the fears or untimely interest of the patient.

Tubes.—No branch of radiography demands sharper definition than that for oral diagnosis, and the tube as

the source of radiation has a marked bearing on the quality of the negatives. The inherent characteristics of a tube cannot be materially altered by manipulation, and are analogous to the correction of the lens in photography. Lenses are chosen for definite purposes; likewise in radiology tubes should be selected for a specific use.

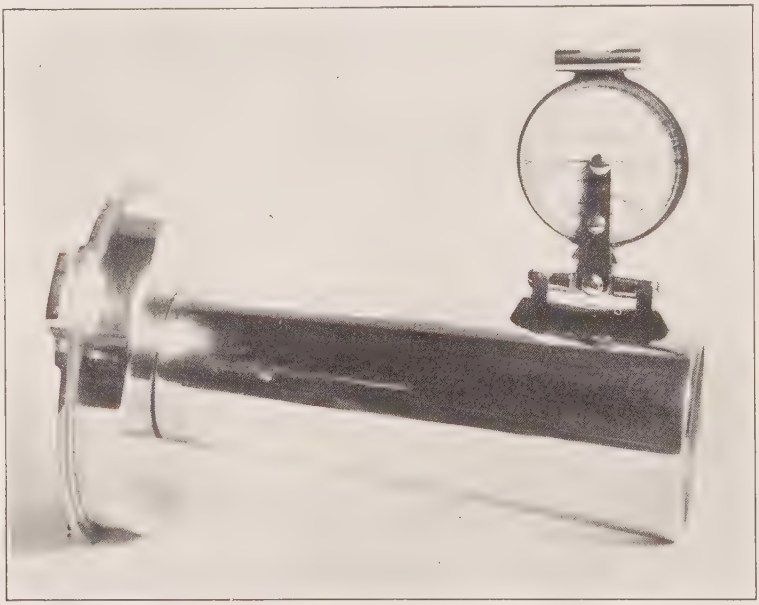


Fig. 7.—The Raper angle meter which may be attached to any cone or pointer for determining the vertico-horizontal angle.

The gas or ordinary tube has almost become obsolete through the popularity of the Coolidge or electron tube with its advantages of stability and ease of operation. However, the gas tube gives a characteristic radiation most gratifying in contrast and definition, which compensates for the difficulties incident to its use. With reasonable experience and care gas tubes can be utilized in radiodontia without great inconvenience, but this state-

ment is not intended to tempt anyone who is satisfied with the properties of Coolidge tubes.

The precautions in operating gas tubes are a period of seasoning to stabilize them and the avoidance of excessive heating or reduction of the vacuum. The seasoning is accomplished by a repeated gradual heating of the tube and after two or three exposures, allowing it to cool. Any reduction required in the early use of a tube must be made on the lowest voltage of the transformer and the wire detached from the reduction chamber before making exposures. As the tube becomes harder from use, the voltage for reduction is gradually increased and the wire left attached to the chamber unless the penetration drops below the desired amount. When it becomes necessary, a tube may be reduced with the same voltage as used for exposures, which is a method generally supposed to be destructive to the tube but in practice extends the period of service from a hard tube.

Coolidge or hot cathode tubes are entirely mechanical in operation and require no special skill or experience. The cathode filament must be heated before the secondary current will pass through the tube, and the milliamperage is governed by the degree of heat which is controlled by the filament rheostat with precision in the absence of line fluctuation. By determining the proper setting of the filament rheostat and the transformer rheostat controlling the voltage, the tube operation becomes merely a matter of closing switches. The manipulation has been further simplified in unit apparatus by having the filament circuit closed automatically by the transformer switch.

The Focal Spot. The size of the focal spot, or area of the target upon which the cathode stream is focused, is the most decisive feature of tube construction, in determining the character of radiographs. With other factors constant, a small focal spot produces an image which is

sharper in definition and more nearly the true size of the object than would a large focal spot. There is no standard gauge for focal spots but those less than 5 mm. in diameter would generally be considered fine; those from 5 mm. to 8 mm., medium; and those over 8 mm., broad.

After a tube has been used for a time the target will show a marking from the impact of the cathode stream which is the approximate size of the focal spot. An accurate method of determining the size of the focal spot is to interpose a sheet of lead with a pinhole equidistant

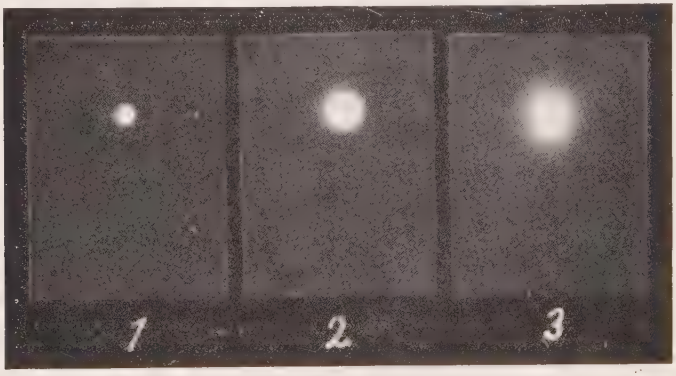


Fig. 8.—Radiographic images of focal spots obtained by the method illustrated in Fig. 10. The first is of a tube most desirable for intraoral radiography. The second is of a serviceable tube, but about the largest focal spot indicated for intraoral radiography. The third is of an inferior tube which will not produce sharp definition because of a flare or wavering of the focal spot.

from the target and film, and radiograph the source of the rays. The lead need not be more than $\frac{1}{16}$ of an inch thick, the pinhole should be the size of a No. 10 needle, and the sides of the opening slightly reamed to remove irregular margins. If the lead is placed about 12 inches from the target and film and an interrupted exposure of 45 seconds made, any wavering of the focal spot will be registered. A striking illustration of the effect of different focal spots may be shown by radiographing a

wire or a wire screen suspended halfway between the target and film.

The requirements of intraoral radiography indicate the finest focal spot practicable, which is about 2 mm. for 10 ma.; 3 mm. for 20 ma.; and 4 mm. for 30 ma., with a spark gap of 4 to 5 inches. The target will be fused by a focal spot smaller than the above proportions, unless short interrupted exposures are used to permit the dissipation of heat. In ordering tubes the size of the focal spot and the milliamperage used should be specified and proved by test before acceptance, and it will be found that the focal spot usually increases in size from use. Tube manu-

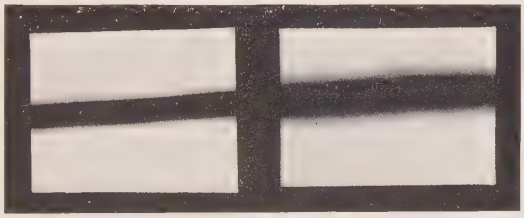


Fig. 9.—Wire test of a fine and a medium focal spot.

facturers are disinclined to supply tubes with a small focal spot because the difficulty in adjusting a fine focus limits the production, and improper use of such tubes is likely to cause complaint. Consequently, little dependence can be placed in a "fine focus" label on a tube, or a convincing statement to that effect by the dealer. Know the type of tube suitable for your work, insist upon getting it, and do not abuse it.

The tube must be placed in holders of the stand so the focal spot coincides with the center of the diaphragm and cone openings for the central rays to parallel the longitudinal axis of the cone. If the focal spot is far from this location, the diaphragm will intercept the radiation through a part of the cone and lead the operator

to believe the cone was not properly centered. Any discrepancy in centering the focal spot alters the angle of projection from that indicated by the cone. The angles of projection specified in the technic of examinations

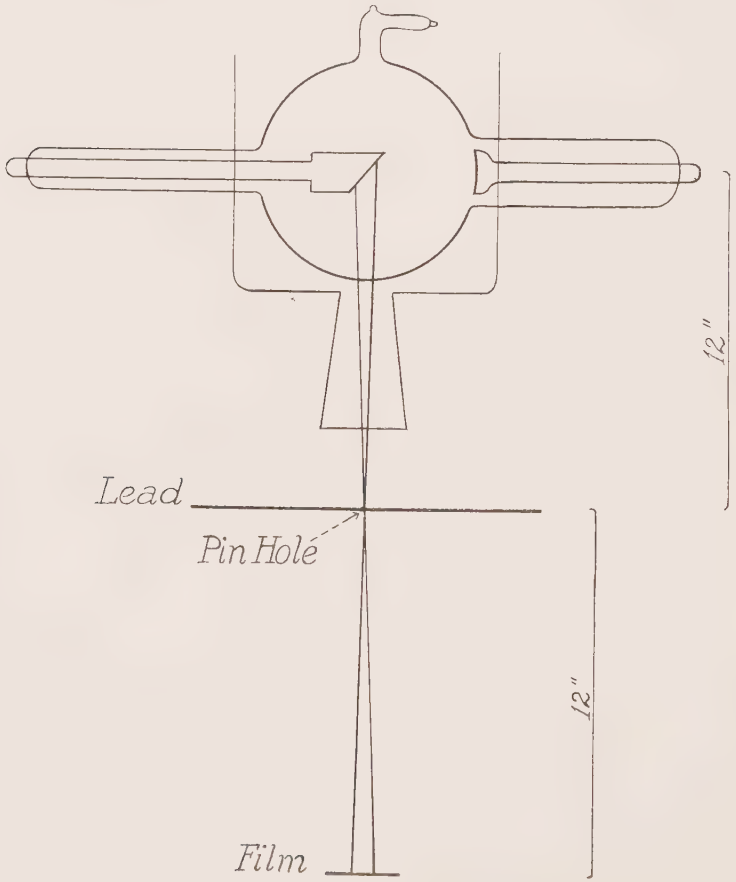


Fig. 10.—A method of radiographing the focal spot.

describe the direction of the central rays from the target toward the point upon which the cone is centered, and should be indicated by the longitudinal axis of the cone.

To center the focal spot, look through the cone at the

tube target sighting along the inner edge of the cone and diaphragm on one side and then on the opposite side, and moving the tube until the focal spot is equidistant from the sides of the cone and diaphragm. If the tubes are frequently removed, a mark should be made on the stem of the tube indicating the location of the holder to center the focal spot.

To determine the accuracy of angle calibrations on a tube stand or angle meter, direct the cone downward and suspend a plumb line through the diaphragm and cone. When the line hangs in the center of the diaphragm and cone openings the angle of projection would be vertical. From this basis the horizontal and intermediate angles can be ascertained by a protractor, or measurements on the circumference of the calibrated disc of the tube stand.

The Chair.—Apparently there is no unanimity of opinion on a suitable chair for oral radiography. Some operators use a "specialist's" chair, others a straight-back chair with a detachable headrest, and illustrations of apparatus even show the patient standing for the examination.

After experimenting with many styles of special chairs, the writer has found a dental chair the most efficient and convenient. The advantages of the modern dental chair are: stability, ease and range of adjustment, revolving without changing the distance from the tube stand, and more comfort than other operating chairs. The objection of the metal parts acting as an electric conductor is incomparable to the "grounded" metal tables which have been universally used by general radiographers, and the possibility of secondary radiation from the metal is excluded by the lead backing of film packets. In using a dental chair for radiography some operators have dispensed with the entire footboard, but this too greatly detracts from the comfort of the patient, and

subsequent illustrations of positions will demonstrate how to avoid interference with the tube stand.

Cuspidor.—A fountain cuspidor should be provided for use during radiodontic examinations as other dental operations. The most convenient cuspidor support for this purpose is a folding bracket from the wall. If the joints of the bracket are lubricated the cuspidor may easily be placed in service or pushed back to the wall. Cuspidor stands or operating units beside the chair greatly interfere with most radiographic equipment, and the attachment of a cuspidor to the chair is contraindicated because of the increased danger of electric shock by the grounding of the chair.

CHAPTER II

GENERAL CONSIDERATION OF INTRAORAL EXAMINATIONS

Advantages.—The advantages of intraoral examinations over extraoral for the teeth and alveolar processes are: convenience in posing, accessibility to all regions, and better definition in the negatives. With the patient sitting erect in an operating chair, by merely changing the position of the head and rotating the chair, all poses for an intraoral examination may be secured. Direct access is available for examination of any region of the alveolar process, with the least possible interference from other structures. The definition in intraoral negatives is favored by the nearness of the film to the parts being examined, and the minimum amount of superimposed tissue.

Technical Requisites.—A "good picture" does not constitute an examination of a region, neither does a profusion of technically imperfect radiographs, which leads to an enumeration of the essential qualities in radiographic negatives and examinations. The technical requirements of radiographic negatives are: (1) Covering the field of examination to the best advantage. (2) Showing no evidence of mobility during exposure. (3) Showing a diagnostic view of the region with the minimum distortion of the image. (4) Showing the maximum definition and contrast consistent with penetration of the structures. (5) Freedom from stains and abrasions. (6) Presenting a symmetrical projection of the image on the film.

Objective.—The objective of an intraoral examination is disclosing for diagnostic purposes the following structures: (1) An extensive periapical area to observe structural changes, and reveal foreign or anomalous bodies. (2) The roots of the teeth with approximate accuracy, to determine the number, size, form, and location. (3) The lamina dura entirely around the profile of the roots, which is a significant diagnostic index often indistinguishable because of technical deficiencies. (4) The crest of the alveolar process to reveal marginal destruction earlier and more accurately than by clinical inspection. (5) The pulp chambers and canals to determine the relation of the pulp to cavities and restorations, the access and course of canals for operations, and the relative efficiency of canal operations. (6) The approximal surfaces of the teeth to detect caries and deposits, and to observe the relative contact of the teeth and the contour of restorations.

To attain this objective and verify the evidence, two or more views of a region are required. When anatomic or operative difficulties are encountered, the examination should be continued to the limit of safe exposure or until every plan to obtain the information has been tried.

Utility.—Examinations which consistently approximate this standard are indispensable in oral diagnosis, and with negligible exceptions are an aid to all dental operations. Radiography is utilized to the full extent of its possibilities by few dentists, and too commonly is it neglected until complications with the probability of irremediable consequences arise. Since the x-rays offer means of inspection which supplements all other methods of examination, its use is an imperative *routine* procedure in dental practice, instead of being the last resort in severe disturbances and unsuccessful operations.

The value of periodic clinical examinations as a prophy-

lactic measure is generally recognized, yet this is only a partial investigation of conditions which may lead to a false conclusion of security. Many features of a clinical examination can easier and more thoroughly be accomplished by radiography, which in addition may reveal vitally important information otherwise unobtainable. A mirror and explorer examination is especially inadequate for patients in whom oral sepsis is suspected by the physician, when the dentist's opinion is solicited in clearing the diagnosis. When the efficiency of dental operations is so dependent upon obscure factors, it is inexcusable to omit any precaution to safeguard the results. Appraised as a conserver of function and health, radiodontic examinations are an economic service far exceeding the expenditure involved.

Radiographic Landmarks.—The regional anatomy has a distinct significance not only in interpretation, but in radiodontic examinations. There are several radiographic landmarks which present anatomic limitations in examination, identify negatives of edentulous regions, and produce confusing radiographic images. In the maxillary incisor region the *nasal spine* and *septum* present a radiopaque area between or above the central incisors; the *nose* obscures with a sharp line of demarcation an area which may include the roots of all the incisors; the *nostrils* form radiolucent zones suggestive of bone destruction over the incisors, the *incisive foramen* is recorded near the roots of the central incisors; and the *incisive fossae* cause a diffuse radiolucence around the lateral incisors.

In the maxillary cuspid region, the *levator muscles* when contracted or abnormally developed produce a fold of tissue with a diagonal line of demarcation about the middle of the cuspid root, which accentuates the increasing thickness of the alveolar process from the lateral

incisor to the bicuspid region, and the base of the *palatal process* presents a radiopaque horizontal line well above the roots of the teeth.

In the maxillary molar region, the *malar process* produces a U-shaped radiopaque line over the first and second molars; the *malar bone* increases the radiopacity over a large area in the second and third molar region; the *maxillary sinus* presents an extensive radioparent

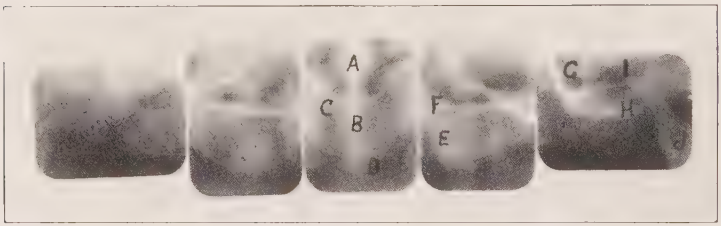


Fig. 11.—An illustration of radiographic landmarks in the maxillary regions. *A*, nasal spine and septum; *B*, incisive foramen; *C*, nostril; *D*, tip of nose; *E*, fold of tissue from muscular contraction; *F*, base of palatal process; *G*, malar process; *H*, malar bone; *I*, maxillary sinus; *J*, coronoid process.

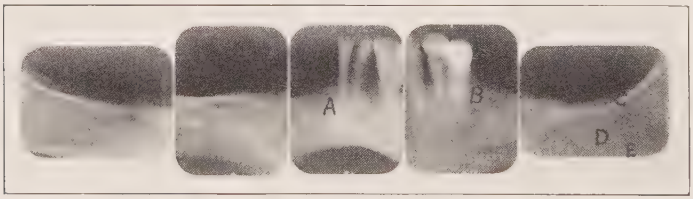


Fig. 12.—An illustration of radiographic landmarks in the mandibular regions. *A*, mental protuberance; *B*, mental foramen; *C*, external oblique ridge; *D*, mandibular canal; *E*, thin portion near the angle.

field which adds to the difficulty in determining periapical conditions of the bicuspids and molars; and the *coronoid* process is superimposed in the third molar region.

In the mandibular incisor region, the *mental protuberance* increases the radiopacity below the teeth, and obscures the apical area when the chin is prominent or a labial inclination of the incisors compels a low angle of projection.

In the mandibular bicuspid region, the *mental foramen* is recorded as a circular radiolucent spot near the apex of the second bicuspid, with the mental branch of the mandibular canal usually traceable to the foramen.

In the mandibular molar region, the radiopacity of the *external and internal oblique ridges* are superimposed on the third molar and may obscure the roots when there is a pronounced lingual inclination of the tooth; the *mandibular canal* with its radioparent lumen is near the apices of the second and third molar roots; and the thin portion of the bone is uniformly more radiolucent as the *angle* is approached.

Advantages of a General Radiodontic Examination.— There are many advantages in making a general radiographic survey of the teeth and alveolar processes, instead of limiting the examination to the region of disturbance or a few teeth which may be under suspicion. Referred pain is so characteristic of the distribution of the fifth cranial nerve, that symptoms are often unreliable in locating the source of irritation, and a limited examination may leave important diagnostic information undisclosed. A general radiodontic examination rarely fails to expose some unsuspected abnormality or pathologic alteration, and leads to the correction of conditions. The discovery of obscure caries or incipient marginal destruction before irreparable damage has occurred, is of the greatest service to a patient.

Furthermore a radiodontic examination must not be depreciated when it does not reveal startling information, or explain existing symptoms, for it is no less useful in excluding possibilities and promoting a correct diagnosis. A general survey also has advantages in facilitating interpretation by giving the opportunity for comparison of different regions, showing the anatomic modifications of the individual, and acquiring a store of radiographic

data for study and subsequent application. When disturbances arise, radiographic records of a patient over a long period are most helpful in distinguishing structural changes, in deciding upon the treatment to apply, and in judging the prognosis. A lamentable handicap in radiodiagnosis is the dearth of material for study and accurate deduction, due to the limited use of routine radiodontic

Fig. 13.—The sixteen views of a systematic general radiodontic examination as described in the text.

examinations. One is constantly confronted by problems of etiology, chronicity, and resistance, even to questioning whether disease has developed in spite of treatment or as the result of treatment, and former radiographic records would be invaluable in deciding the issue.

Outline of a General Radiodontic Examination.—A survey of sixteen views is proposed as the minimum re-

quirement of a general radiodontic examination. The systematic division of the dental arches into the sixteen areas to be described, tends to eliminate the usual confusing structures, and gives two or more views of each tooth excepting the third molars and the mandibular central incisors. The third molars are often absent, and the mandibular incisors are rarely the seat of disease other than marginal destruction which is readily disclosed in this region.

Three views are allotted to the maxillary incisors: one approximating the median line, grouping the incisors in the most favorable aspect; one directed at the left central and lateral incisors; and another directed at the right central and lateral incisors. The mandibular incisors are viewed in a direction conforming to the general inclination of these teeth. Each of the cuspids is shown in a separate view which includes an eccentric or diagonal aspect of the lateral incisor and bicuspids. One view is assigned to each of the first molars, including the adjacent bicuspids and a diagonal aspect of the second molar. The second and third molars in each molar region are viewed from the most accessible point which also gives an eccentric presentation of the first molar.

A general examination is intended as a routine inspection and not necessarily complete in that many conditions require extraoral examination, exploratory probes, or some means of localization; while for refined diagnosis, canal operations or surgical treatment, an exhaustive x-ray examination of a region may be indicated.

CHAPTER III

SYSTEMATIC PROCEDURE

Orderly Procedure.—Systematic procedure commands the confidence and cooperation of the patient, expedites the operation, and is conducive to superior results. With a little training, orderly methods will become a habit and a constant source of satisfaction.

All preparations for the examination should be made before the patient is ushered into the room. These preliminaries include the preparation of the chemical solutions in the dark-room, testing of the apparatus, providing a supply of films in the customary protected location, and arrangement of the light and ventilation. The operator's hands should be washed while the patient is being seated, so he can proceed at once with the clinical examination.

Preliminary Inspection.—The first step is a general inspection of the mouth for removable appliances, abnormalities, pathologic manifestations, and dental conditions. This preliminary inspection usually reveals factors having a direct bearing on the x-ray examination, and is the means of avoiding many subsequent complications. Spectacles, artificial dentures and other impedimenta should be deposited in a safe place to prevent their falling or being a cause of distraction.

Precautionary Measures. The patient should then be questioned about recent exposure to radiation, as a precaution against excessive exposure in this era of promiscuous and incompetent oral radiography. This information may be obtained without exciting fear, by asking if the patient is familiar with the operation, and

when the answer is in the affirmative, by asking how recently and to what extent radiation has been applied. In case the patient has recently been subjected to considerable radiation, the examination should be deferred until two weeks after the last exposure. If circumstances make a risk of excessive exposure advisable, it should be explained in detail and the consent obtained before proceeding. This discharges the moral obligation, but if legal responsibility is to be fixed, a dependable witness should be present during the conversation.

Allaying Fear.—Radiographic examinations are still enough of a novelty for many persons to approach them with curiosity or fear. It is a duty of the operator to allay the fear, and it is of great assistance in securing the necessary cooperation to briefly explain the procedure. To arbitrarily state that there is no danger will likely provoke a citation to the contrary, and to state that it is painless may be disproved to a sensitive patient before the examination is completed. A few words of intelligent explanation will be appreciated, and this should include assurance of protection from electric shock, the comparison of the exposure required for radiography to that which might be injurious, and a promise of no sensation except the discomfort from placing the films in the mouth. To permit these statements being truthfully made, have equipment, manipulative skill, and sufficient knowledge of x-ray dosage to give the greatest degree of safety.

Having the transformer some distance from the chair, and in the unit types designed to extend over the chair from the rear, having the tube reversed so the transformer will be in front of the patient will reduce the fear of concealed danger and proximity to electric apparatus. Passing the current through the tube to familiarize children and nervous adults with the effect before posing them aids in relieving the tension.

Beginning the Examination.—The patient should be posed and the tube adjusted to approximately the desired position before the film packet is placed in the mouth, so the period of retention will not be unnecessarily prolonged. Then the film packet is placed in position, the final adjustment of the tube made, and the exposure begun as rapidly as possible.

The first exposure is more likely to result in failure than subsequent ones because of the patient's inexperience, and the instructions must emphasize the necessity for cooperation. When several regions are to be examined, the one presenting the least difficulty to the patient should be radiographed first.

Sequence of Regions.—Systematic methods are especially indicated in general radiodontic examinations for uniformity and thoroughness. By radiographing the regions in the following order, there is a marked advantage in anticipating unusual conditions, and determining the most favorable angle of projection by inspection of the negatives from preceding exposures.

Regions in suggested order of examination:

Left maxillary cuspid.
Left mandibular first molar.
Left mandibular second molar.
Left maxillary first molar.
Left mandibular cuspid.
Mandibular incisors.
Right mandibular cuspid.
Right maxillary cuspid.
Maxillary incisors (median view).
Right maxillary first molar.
Right maxillary second molar.
Right mandibular first molar.
Right mandibular second molar.

Left maxillary second molar.
Left maxillary incisors.
Right maxillary incisors.

It is assumed that the films are to be developed as the examination proceeds, for when this is not done the operation is merely guessing at the most favorable aspects, without an inkling of the information being recorded,

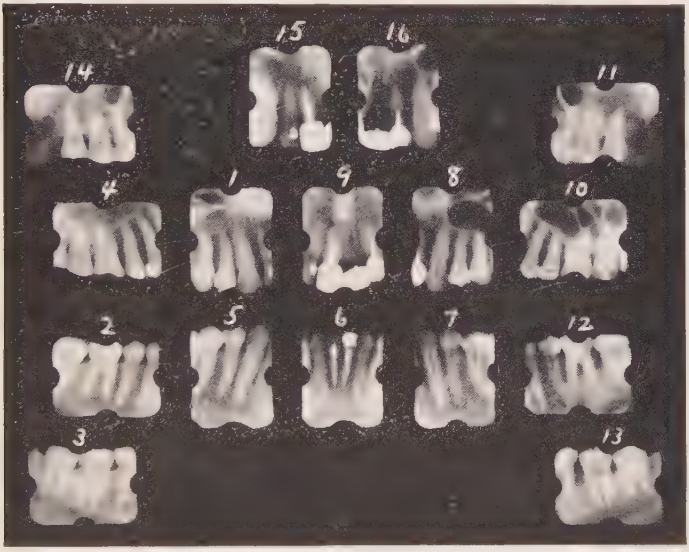


Fig. 14.—Chart showing the sequence of regions suggested for a general radiodontic examination.

and without an opportunity for correction or further investigation, unless the patient remains or returns after development of the films. The exposure of a predetermined number of films at an ultra-safe angle of projection, and dismissal of the patient, is mechanical radiography, not a radiodontic examination. Even when a dark-room assistant is not available, the films should be developed during the progress of the examination.

The advantages in beginning with the left maxillary

cuspid region are: the slight discomfort from the film packet; the accessibility of the region; the opportunity of observing root and bone characteristics in the incisor and bicuspid regions; combining the possibility of misjudging the length of the cuspid root with the uncertainty of the initial exposure; and the use of the patient's right hand in becoming familiar with the retention of the film packet. The mandibular molar regions offer little technical difficulty, and those on the left side may be exposed while the first film is being developed, or they may be developed with the first if the operator must do the developing. When the negative of the cuspid region is ready for inspection, the operator is able to modify the penetration and exposure, and calculate the approximate angle of projection for the maxillary incisors, cuspids, and bicuspids.

The fourth exposure should be for examination of the left maxillary bicuspids and first molars, since the angle of projection must conform to the bicuspid conditions disclosed by the negative of the cuspid region. For convenience in poses and chair manipulation, the left mandibular cuspid, mandibular incisor and right mandibular cuspid regions are next exposed in order, utilizing the information obtained from the negative of the mandibular first molar region. Then the right maxillary cuspid, and the median view of the maxillary incisors are radiographed in conformity to the angulation suggested by the negative of the left cuspid region.

The right maxillary molar regions are next examined as indicated by the record of the left maxillary first molar region. While these are being developed the right mandibular molar regions are radiographed with any modifications suggested by the negatives of the left side. When the right maxillary second molar negative is ready for inspection, the left can be radiographed with more confidence by correction of any miscalculation. This

leaves the two diagonal views of the maxillary incisors which present little difficulty after studying the median incisor and cuspid views.

This method tends to equalize the exposure of the face to radiation, by dividing the difficult steps of the examination between the left and right sides in determining the general character of the roots and bone on the left, and the most favorable aspect of the maxillary second molar region on the right side. The probability of miscalculation is greatest in the maxillary cuspid and the first molar regions which were first examined on the left side, and the maxillary second molar region which was first examined on the right side. However, there is a possibility of technical errors and movement in any region, and during the examination all negatives should be studied with the motive of obtaining the desired information and correcting technical deficiencies.

Position of the Patient.—An erect posture in the chair is advocated because it is more adaptable to the poses, more accessible to natural light, and less embarrassing to women than a recumbent position. This requires the back of the chair to be vertical, and any compromise by inclining the back or chair, complicates the poses.

Since immobility is imperative to the success of the examination, the patient should be comfortably seated, and adequately supported by proper adjustment of the chair. Comfort and relaxation greatly contribute to muscle control and ability to obey instructions, without which the most earnest and skillful efforts of the operator will be futile.

Position of Head.—The pose of the head is a fundamental factor of the systematic technic herein described. A system of angulation must have a base for calculation, and the occlusal plane of the teeth is advocated by the

Fig. 15.—Illustrating the use of occlusal plane level in posing for maxillary regions.

Fig. 16.—Illustrating the use of occlusal plane level in posing for mandibular bicuspids and molars.

writer as the most accurate and rational basis for angulation in intraoral examinations.

For examination of the maxillary regions, the head is posed so that the occlusal plane of the maxillary teeth anteriorly from the first molars, is horizontal. For the mandibular molar regions, the head is posed so that the occlusal plane of the mandibular teeth is horizontal when the mouth is open for retention of the film packets. For

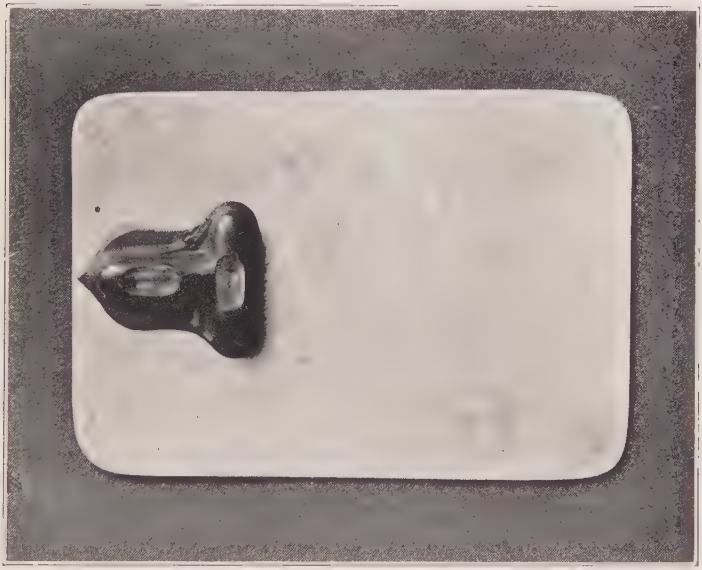


Fig. 17.—An occlusal plane level, made by attaching a two-plane camera level to a piece of aluminum. This was made for demonstration, and is not used in operating.

the mandibular incisor and cuspid regions, to avoid proximity to the tube, the head is further reclined with the occlusal plane laterally horizontal, until the longitudinal axes of the teeth in the region to be radiographed are vertical, anteroposteriorly.

The poses may be demonstrated and verified with a two-plane spirit level attached to a flat metal plate which is rested on the cusps of the teeth. In practical operations

after a little training, the positions can be obtained without mechanical aid, and the mean occlusal plane approximately leveled with due compensation for inequalities in cusp elevation.

Application of the System.—The favorite textbook rule for projecting a true image of the teeth, is to direct the rays perpendicular to a line bisecting the planes of the film and teeth. This rule has a mathematical ring which inspires confidence, the diagrams illustrating the method are convincingly simple, and the principle is correct, but what of the practical application? The plane of the film packet can be seen only with difficulty and not from a favorable position, for calculating the angle of projection. The plane of the teeth cannot be seen, but only surmised from the position of the crowns. The bisecting line is an imaginary plane to which the incidence of the rays must be calculated. Therefore with this method the cone is to be directed so that the imaginary central rays are parallel to an imaginary line, which is perpendicular to an imaginary plane bisecting the angle formed by the problematical plane of the teeth, and the obscure plane of the film. This deceptive rule and illustrations showing the results of incorrectly directing the rays to produce marked elongation or foreshortening of the image, have been the customary instruction in the technic of projection, leaving the application to individual conception and application which have not proved adequate.

A system of projection based on the position of the teeth in relation to the occlusal plane requires consideration only of the inclination of the teeth and the comparative root length, and provides a precise method for correction in case of miscalculation, or for subsequent reproduction. Average angles determined by statistical records, with modifications for exceptional conditions,

will be stated for each region to serve as a dependable guide in learning the system.

The occlusal plane as a base offers advantages in that it is visible to the operator when calculating the angle of projection, and placing the film packet; it is independent of facial asymmetry, either profile or bilateral; it is applicable both to the anteroposterior and lateral posing;

Fig. 18.—An example of the variance in the occlusal plane, and the ala-tragus base for angulation. In this instance with the occlusal plane horizontal a line from the ala of the nose to the tragus of the ear inclines approximately 15 degrees upward, which would make a corresponding difference in the angle of projection.

and it is the plane which establishes the inclination and the relative position of the teeth. The position of the teeth or their inclination in relation to the occlusal plane is the most influential factor in calculating the angle of projection to produce the desired image. It has been generally and erroneously believed that the height of the vault decisively determines the direction of the rays in

radiographing the maxillary teeth, but an extremely narrow arch and exostosis at the median raphe of the hard palate are the only variations in form which demand compensating angles.

The walls of the vault are formed by the alveolar process which is developed for the support of the teeth, and conforms to the size and position of the teeth. When

Fig. 19.—An example of the variance in the occlusal plane base for angulation, and the external landmarks. In this instance when the occlusal plane is horizontal the right eye and ear are much higher than the left, which would make a material difference in the vertico-horizontal angles of projection.

the tooth roots are short, the alveolar process is correspondingly developed and the vault is low. With a high vault which is generally supposed to be favorable for intraoral radiography, the roots are proportionally long, and the direction of the rays to produce an accurate image will not greatly differ from that in other examinations. When the vault is wide and apparently low because of a

marked buccal and labial inclination of teeth, the rays must be directed at greater vertico-horizontal angles, but the position of the teeth instead of the height of the vault determines the angles. In contrast, the narrow "V" shaped arches usually form extremely high vaults, yet the rays must be directed from a high point because of excessive bending of the film packets in the narrow arch.

Exostosis at the suture of the palatal processes prevents adaptation of the film packets to normal curve of the palate and demands compensation in calculating the angle of projection. This hyperplastic abnormality occurs in about 12 per cent of adults, according to the investigation of Dr. Arthur B. Crane, who originated and perfected the operation for its correction.

Operation of Tube Stand.—The greatest efficiency and convenience cannot be obtained from the tube stand without a definite plan of operation. The weight essential for stability and balance in a tube stand offers considerable inertia, but the labor can be rendered negligible by systematic manipulation. By placing the tube stand slightly back of the chair on the side nearer the transformer, and turning the chair for the different regions, slight change in the location of the stand will be required for intraoral examinations. Placing the stand on the side nearer the transformer saves steps, since the angles should be calculated and the stand adjusted from the side of the chair on which the tube is located. This particularly applies to the mesio-distal angles, which can be best obtained by sighting along the cone.

Assuming that the tube stand is placed at the right of the chair, although there is no advantage even to a right-handed operator, the right molar regions are radiographed with the chair in the customary position for clinical examinations. For the right cuspid regions, the chair is rotated about 45 degrees to the right, for the in-

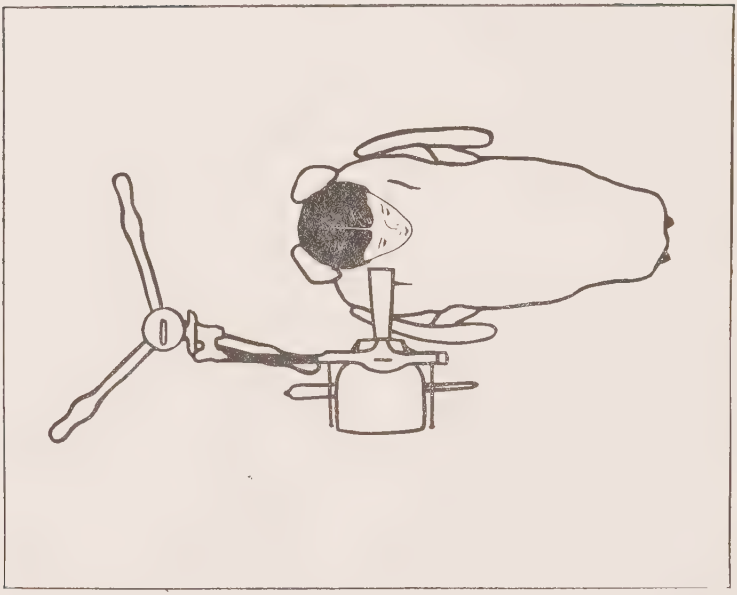


Fig. 20.—Position of chair and tube stand for right molar regions.

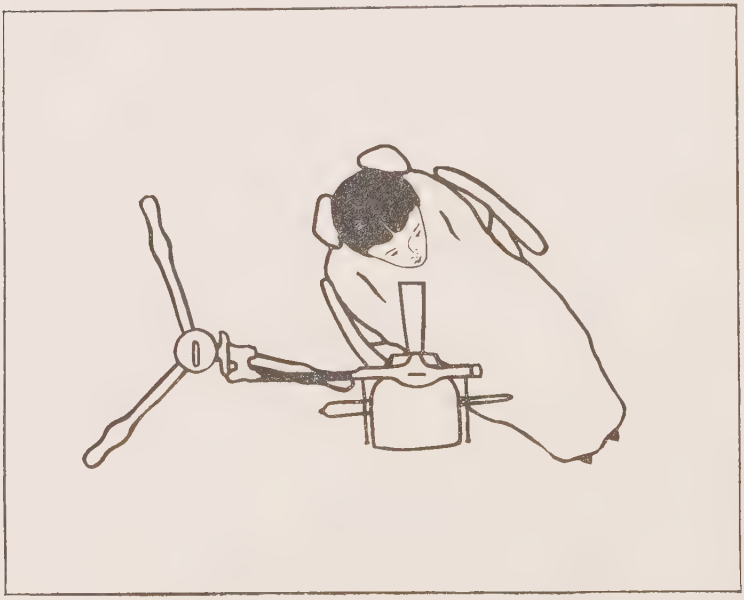


Fig. 21.—Position of chair and tube stand for right cuspid regions.

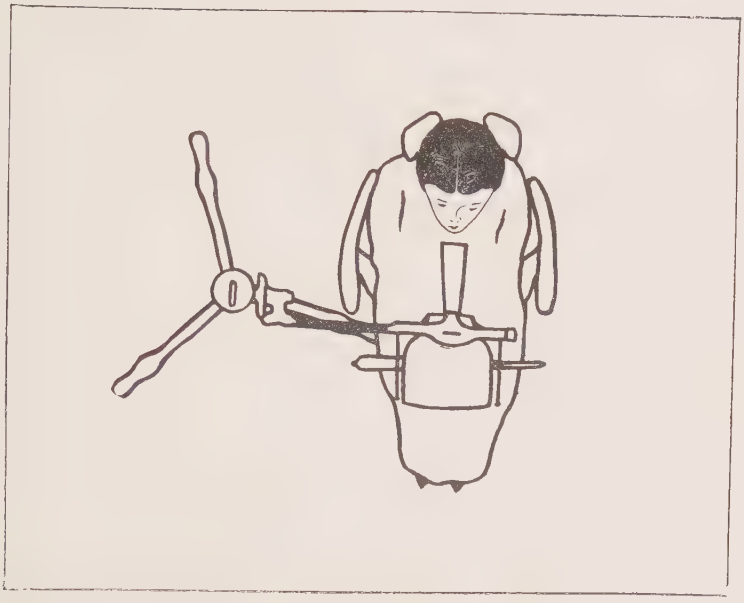


Fig. 22.—Position of chair and tube stand for incisor regions.

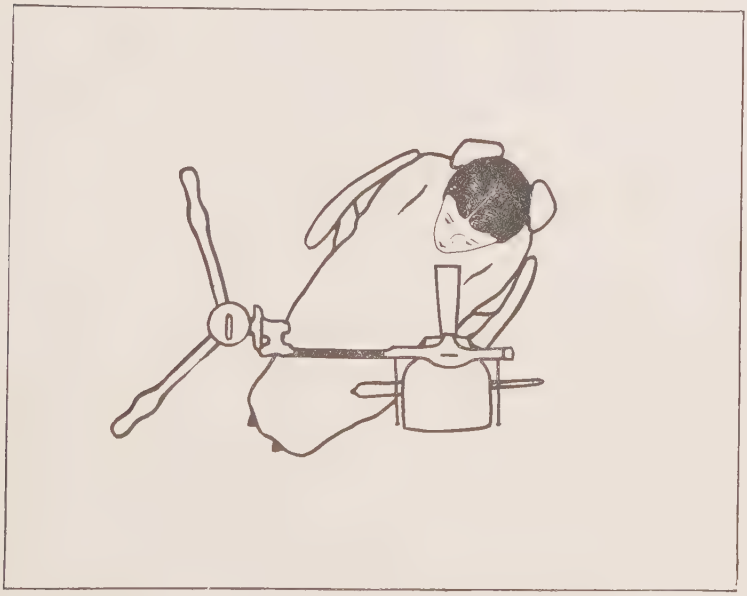


Fig. 23.—Position of chair and tube stand for left cuspid regions.

cisor regions 90 degrees to the right, and for the left cuspid regions 135 degrees to the right. For the left molar regions, the chair is rotated in the opposite direction 180 degrees to the left from the original position. With tube stands having an adjustment which changes the mesio-distal angle of projection, little turning of the

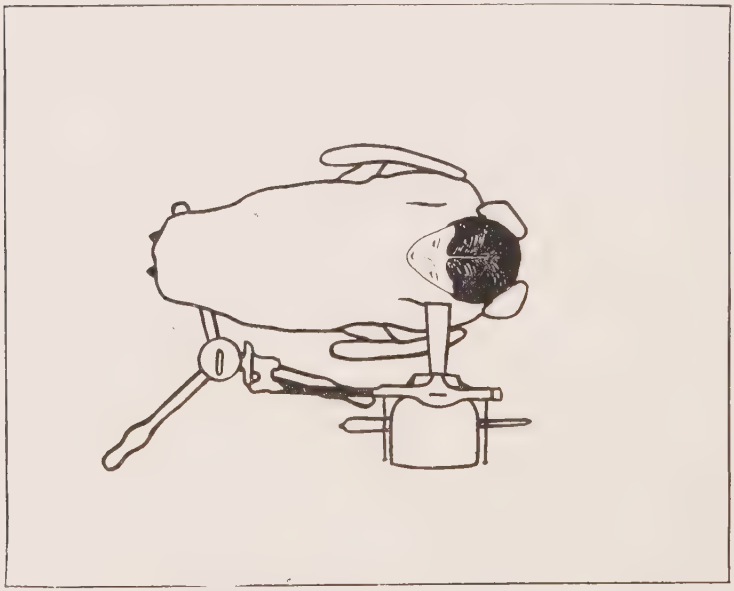


Fig. 21.—Position of chair and tube stand for left molar regions.

head will be necessary, and uncomfortable poses will be avoided.

The approximate position of the chair and adjustment of the tube stand should be arranged before placing the film packet. To accomplish this, the position of the teeth in the region should be closely observed and the angle of projection calculated, vertico-horizontally in degrees and mesio-distally in relation to dental landmarks. Then rotate the chair to the desired position, adjust the head rest so that the head is correctly posed, adjust the tube

stand for the vertico-horizontal angle and approximate mesio-distal angle, and swing the tube carrier aside to permit access for placement of the film packet.

Target-Film Distance.—The target-film distance is an important factor in the perspective and definition of radiographs because of the divergence of x-rays. With

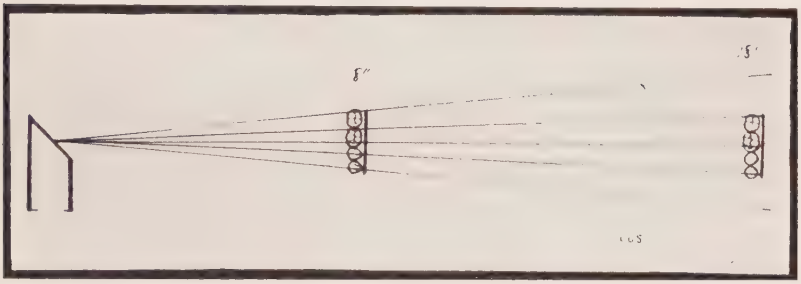


Fig. 25.—A diagram true to scale illustrating the greater divergence of the rays which produce an intraoral radiograph at an eight-inch target-film distance than at eighteen inches.

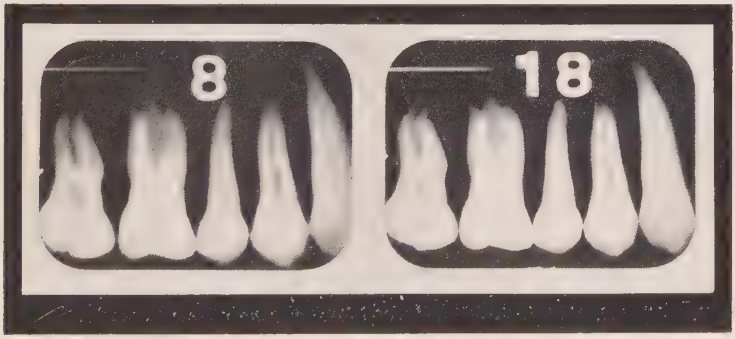


Fig. 26.—Test radiographs of extracted teeth and a barbed broach at an eight and an eighteen inch target-film distance. The distortion which projects part of the cuspid off the film and the inferior definition in the image of the broach at eight inches are characteristic of short target-film projection.

the angle of projection and the relation of the object and film constant, increasing the target-film distance improves the definition and perspective and produces an image more nearly the true size and form of the object. Were it not for the necessary increase in exposure and penetra-

tion a target-film distance of ten feet would be advantageous but the inability of patients to maintain immobility for long exposures counteracts the advantage of an excessively long distance.

At a target-film distance of 8 inches, which is used with the three inch dental units, there is a divergence of eleven degrees in the rays at the opposite ends of a No. 1 dental film. This diversity of eleven degrees in the angles of projection results in a confusing distortion of the image and seriously impairs the diagnostic value of the radiographs.

The target-film distance of 18 inches which is specified in the technic of intraoral examinations gives a divergence of only five degrees and serves as a compromise in distance and exposure for "regular" films. With tubes which accommodate more than 20 milliamperes, a greater distance is permissible. For extraoral examinations 40 inches is advocated because of the more extensive field with a proportionally greater divergence of the rays.

Covering Film Packets.—It is inconsistent with the present aseptic standards of practice to place a film packet of unknown sanitary history and environment in a patient's mouth. The packets are placed in contact with mucous membrane occasionally producing abrasions with hemorrhage in spite of careful manipulation, they are adapted and held in the current of inhaled air, and they are bathed in the saliva. This introduction to mucous surfaces, the respiratory tract, and the alimentary canal leaves only intravenous injection as a more favorable means of inoculation. Film packets are manufactured with only ordinary industrial sanitary precautions for photographic material, and are dispensed without aseptic claims.

Since the packets cannot be sterilized without injury to the emulsion on the films, the logical alternative is to

cover them with a sterilized wrapper. This may be readily done by the following method which the author has followed for several years. Paper, listed as "Saturn Parchment 25 pound" by the Graham Paper Company, size 8½ x 13 inches is procured from a stationery dealer. These sheets are cut into eight equal parts which are a

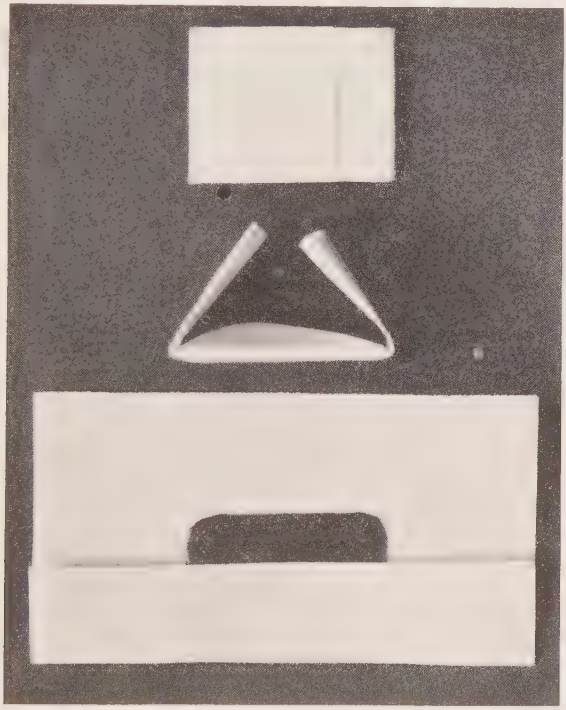


Fig. 27.—Illustrating the method of wrapping film packets in sterilized tissue paper.

suitable size for the regulation No. 1 film packets. For the No. 2 packets the sheets are cut in half, and for No. 1A quartered. The cut paper is stored in a formaldehyde sterilizer for weeks before being used. Prolonged rather than rapid sterilization is necessary, for when the packets are wrapped in paper from which the odor of formaldehyde is detectable, the emulsion at the edges of the film is

likely to be so hardened as to resist the developing solution.

The packets are tightly wrapped as the druggist wraps the individual doses of a powder formula and the ends telescoped to retain them, the wrapping being done by clean hands on a freshly laundered towel which is kept in the sterilizer. It requires about an hour to leisurely wrap a gross of the packets, and a few minutes employed at convenient times will maintain a reserve supply which is placed in a covered glass jar in a convenient protected location.

Other than cleanliness, the advantages of the covered packets are the adhesion of the paper to the moist mucous surfaces which aids in retention, the greater visibility of the packet, the cushion effect of the thin paper covers, and the protection of the packet from the saliva. When the packet is removed from the mouth, the covering is torn off leaving a dry packet to open in the dark room. Assistants consider the privilege of handling dry packets a bountiful compensation for the wrapping.

Placement of Film Packets.—The position of the film packet establishes the location of the image on the film. This is not a vital matter so long as the important structures are recorded, but it does determine the uniformity of the result and demonstrates the proficiency of the operator. Excessively large areas of distorted image with a wind-blown aspect or a grotesque placing of the image on the films, stamps the operator as a bungling novice, and is confusing to observers accustomed to uniform negatives. The method of inserting and adapting the film packets in the mouth, controls to a great extent the discomfort experienced by the patient, and the facility of the operation. The tendency of nausea from the presence of the packets in posterior regions is reduced by dexterity in the placement. Having the patient hold

the breath for long periods relieves the symptoms, and when the idiosyncrasy is pronounced an Anesthesin-Calcidin troche (Abbott) dissolved on the dorsum of the tongue is a most effective remedy.

Having previously decided upon the position of the packet, the corner or corners which will encounter the most resistance are slightly bent to relieve the discomfort, and permit an easier adaptation of the packet. Excepting in the maxillary molar regions where nausea may be produced, the packets should not be placed by a single movement, but by two or three steps to gradually conform the packet and in the mandibular regions to displace the soft tissues. In adapting the film packets, they should be bent only enough to bring them into the closest possible relation to the roots of the teeth. Excessive bending is to be avoided, but when intraoral films are placed without bending, an objectionable space is left between the films and teeth and the plane of the films proportionately recedes from parallelism with the plane of the teeth. Theoretically a flat surface upon which to record the image is preferable, but in practice the advantage is overbalanced by the impaired definition in the negatives as the distance between the film and object is increased, and the altered aspect of a foreshortened view. Since a flat film cannot be placed so nearly parallel to the teeth as one slightly curved, the angle of projection must be more acute in relation to the roots, and the longitudinal view of the teeth and contiguous structures is usually the most valuable. Intentional distortion on the curved portion of the films may be ignored in studying them but a loss of detail and an unfavorable aspect are serious handicaps in interpretation.

In placing the packet, cognizance should be taken of where the image of the teeth will be projected upon the films, that they may be shown in the negative and a

symmetrical margin obtained. Since the film area should be utilized as fully as conditions permit, the incisal and occlusal line should be near the corresponding margin and approximately parallel to it. By so doing a liberal periapical region will be included, and the image of the teeth will be correctly placed. In this endeavor, consideration must be given to the angle of projection, the position of the teeth, the greater width of posterior teeth than incisors and cuspids, and the curve of Spee.

Retention of Film Packets.—Although many film holders have been designed for intraoral use, except in the mandibular molar regions none accomplishes the purpose better than digital retention. The thumbs are preeminently fitted to retain packets in maxillary regions, and the first fingers are most effective in mandibular regions. Since 98 per cent of people are right handed and the remainder are more nearly ambidextrous, the patient's right hand should be used for the left and median regions, leaving only the right regions for the left hand.

In the final adaptation of the packet, the first finger of the operator's hand opposite to that which the patient is to use for retention, should rest in the most advantageous location to retain the packet. Then place the first finger of the other hand alongside and in contact with the adapting finger to retain the packet while the adapting finger is replaced by the patient's finger or thumb. With the adapting hand, grasp the patient's retaining hand and carry the thumb or finger to the place indicated by contact with the operator's retaining finger, and demonstrate the amount of pressure required to prevent dislodgment of the packet. To avoid complications, never permit the patient to choose the location of the retaining finger or thumb, but always guide it to place.

After the patient's retaining thumb or finger is placed,

a rest should be provided for the hand to aid in perfect retention. In maxillary regions where the thumb is used for retention, the fingers should be firmly rested near the temple. For mandibular regions where the first finger is used for retention, the thumb should press on the lower border of the mandible far enough from the film packet to carry the unemployed flexed fingers clear of the field.

To elucidate this description, the following are specific examples. In the maxillary left cuspid region, the packet while being held near the lower end by the right first finger and thumb is adapted by the operator's left first finger. After the left first finger has found the most advantageous location for retention the right first finger is moved into contact with it to hold the packet. Then with the left hand the operator grasps the patient's right thumb, and places it in the location just vacated by the operator's left first finger, and places the patient's right fingers near the right temple. In the mandibular right cuspid region, the packet while being held near the upper end by the left first finger and thumb is adapted by the operator's right first finger. After the right first finger has found the most advantageous location for retention, the left first finger is moved into contact with it to hold the packet. Then with the right hand the operator grasps the patient's left first finger and places it in the location just vacated by the operator's right first finger, and places the patient's left thumb on the border of the mandible below the left bicuspid region.

Final Preparations.—After the packet is retained in position, observe the landmarks for the pose of the head, and make any changes indicated. In posing the head, the face should be firmly grasped with a hand on either side while the lip is retracted by the thumbs. Avoid touching the eyes or ears, because of the disagreeable sensation given the patient. Then swing the tube to place

with care that the cone is centered on the region, make the necessary correction in the mesio-distal angle, and quickly proceed with the exposure.

Penetration.—There is a conspicuous diversity of opinion in the penetration suitable for radiodontic examinations. The apparent discrepancies are explainable by differences in recording medium and target-film distance used, perverted standards in the character of negatives, and inaccuracies in calculating voltage. Double coated films and extra fast films require less penetration than "regular" films. With films of equal speed more penetration is required as the target-film distance is increased. Operators with whom contrasty negatives are a fetish advocate low penetration at the sacrifice of detail. The spark gap method of estimating penetration is inaccurate because it is modified by the form of the spark terminals, altitude, and to a lesser degree by the relative humidity of the atmosphere.

The minimum penetration requirement is that which will register the structural detail of the region with the recording medium and operating conditions employed. Considerable latitude is permissible in using a greater penetration than the minimum requirement, without impairing the diagnostic quality of oral radiographs. Deficiency in detail restricts the information sought, while a moderate lack of contrast is not a serious handicap in radiographic study of dental and osseous structures. Therefore it is preferable to slightly err toward overpenetration, especially until the examination has progressed to where the radiability of the patient can be judged.

The penetration recommended in the technical instructions for each region applies to a sharp terminal spark gap at an altitude of 900 feet. The voltage specified was determined by exact voltmeter tests, and when apparatus with voltage calibration is available the spark gap calcu-

lation should be disregarded. The latitude in the suggested penetration is for application to different bone types and even greater modifications are occasionally indicated in extreme types. Refined modern radiographic equipment has voltage control of the primary circuit and the manufacturer can supply a chart of the corresponding secondary voltage. However, the manufacturer's estimate of spark gap voltage should not be followed as this is usually based on the standard 125 millimeter sphere gap.

Exposures.—The exact length of exposure required cannot be stated because it differs with regions, subjects, target-film distance, voltage, amperage, films, and tubes. In the technic for each region, a range of exposure time is estimated in milliampere seconds, which are the milliamperes multiplied by the seconds of exposure. For example, if 20 milliamperes were used and the time was 6 seconds, the exposure would be 120 milliampere seconds.

Since the estimates are for a target-film distance of 18 inches, when a 45 kilovolt machine is used at the customary 8 inch target-film distance, the exposures would be slightly less than one-fourth the milliampere seconds suggested for each region. The exposure mentioned is for the Eastman, Buck, or Bolin slow or "regular" films, which is about four times more than that for extra fast films. The films with emulsion on both sides, which are listed as "radia-tized" by the Eastman Kodak Company, and "intermediate" by the Victor X-Ray Corporation require about half the exposure necessary for slow films.

The timing of exposures can be accurately, conveniently, and safely done with a stopwatch hung on the screen or transformer. A watch which sets the hands by a push on the stem, and stops the hands by a lug on the side is preferable to one which is controlled entirely by

the stem. Regardless of experience, reckoning time by guess or count is likely to be influenced by circumstances, and this factor of error should be excluded.

Pulp Testing.—Contrary to the usual procedure, pulp testing can be done more intelligently and expeditiously after the x-ray examination than before. The teeth which

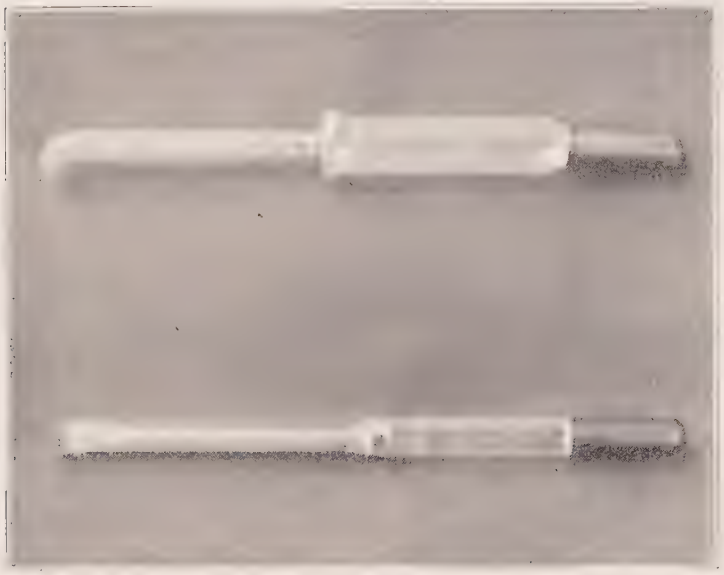


Fig. 28.—High-frequency electrodes suitable for pulp testing. A wire has been inserted to offer less resistance than the vacuum.

are shown by radiographing to be pulpless do not require testing, and special attention should be given to those which are questionable. Most patients resent the testing, and any curtailment of the ordeal possible without neglecting the examination, is desirable. Conditions occasionally demand a partial service in limiting the radiographic examination to the pulpless teeth, and the vitality

test will aid in excluding regions in which periapical disease is unlikely to be present. However, alveolar lesions are found adjacent to vital teeth, degenerating pulps may respond to vitality tests some time after becoming septic, and the evidence of disease from canal origin is only one of the many disclosures to be anticipated from the radiographic examination.

An electric test is more effective than thermal, and high-frequency current offers many advantages over the faradic which has generally been recommended for the purpose. In the use of high-frequency current, moisture does not affect the result; only one electrode is used; contact with the tongue or other mucous surfaces does not cause shock; and application to metal restorations is not noticeably transmitted to the gingiva, or more painful than other locations on vital teeth. Response to the test is reduced in proportion to pulp recession, the insulation of cement and conductivity of gold crowns precludes the testing of crowned teeth unless the cervical portion is exposed, and a remarkable limitation of the high-frequency test is the lack of response from many vital third molars.

The dispatch with which the test can be applied with high-frequency current is attractive, since requesting the patient to hold the neutral electrode for faradic current usually produces a demonstration of electrophobia which requires explanation and persuasion to control. The electric tests for vitality depend upon the sensation from electric stimulus, and the rapid oscillations of the high-frequency coils which have been estimated at 500,000 per second cause more sensation for the voltage employed than the comparatively slow interruptions of the faradic which also tend to produce muscular contraction.

Pulp Testing Apparatus.—Any high-frequency generator may be used for pulp testing, although a delicate con-

trol and a small handpiece are desirable. A small "violet ray" appliance designed for home use will serve the purpose, if supported or attached in a convenient location.

Even the smallest vacuum electrodes supplied with the apparatus are unsuitable for pulp testing because of their excessive resistance to the current, but they may easily be converted into efficient applicators by the following process. Break the glass tip, insert an 18 gauge copper wire to the base of the electrode, and fuse the broken glass tip around the projecting wire. Then cut the wire so $\frac{3}{16}$ of an inch is exposed, curve it to an angle of 60 degrees and polish the point.

This modified electrode conducts the current directly from the glass wall of the base to the tip, and insulates all excepting the exposed end of the wire. The glass wall at the base offers just enough resistance for testing with a small amount of current instead of almost the maximum capacity of the transformer required with a vacuum electrode. Although high-frequency generators are sold for pulp testing, the salesmen resent suggestions of an improved electrode as a reflection on the apparatus, so it will be necessary to remodel the applicator until such appliances are suitably designed for this purpose.

Technic of High-Frequency Tests.—Keen perception and judgment must be exercised in the successful application of all vitality tests. The amount of current required to obtain a response varies with different teeth and individuals, but it bears a rather uniform relation to the size of the teeth. Deciduous teeth and abraded teeth are sensitive to a slight current, while those with large restorations and pulp recession give a doubtful response when the rheostat is fully open.

The tests should begin with a degree of current which cannot be detected, then be gradually increased until sensation is produced in the incisors and cuspids, then in the

bicuspids, and finally the molars. In each region some of the teeth may require more current than others, and these should be retested after the current has been increased for the next region, to save repeated and unnecessary adjustment of the rheostat. The incisal edges and cusps are susceptible points, but developmental pits or the cervical region are more favorable under some conditions. The application of a small piece of rubber dam or strips of rubber between the teeth is indicated when the current used is sufficiently strong to jump to adjacent teeth. For thorough instruction in pulp testing technic, the reader is referred to Raper's "Electro-Radiographic Diagnosis."

Since the preceding description of high-frequency testing was written, the author has adopted a more quiet and efficient testing apparatus, the Cameron Vitalitester. This appliance is a miniature induction coil with a ten-step rheostat and a digital interrupter. The electrode is a curved glass rod with two platinum points separated 2.5 millimeters for circuit contacts on the tooth.

The technic of application is quite similar to that of high-frequency current, but since the platinum points control the path of the current there is less tendency for the current to affect adjacent teeth. To manipulate the apparatus without assistance, the operator should hold the applicator in the right hand and the control in the left for testing the teeth on the left side of the month, and the electrode in the left hand and the control in the right for the teeth on the right side of the mouth. By holding the applicator with the pen grip and retracting the lip and cheek with the third finger, the other hand is free to manipulate the control.

Since the sensitiveness of teeth and individuals differs, the current should be increased only as required for unmistakable response and the interrupter lightly pressed

for the initial test of each tooth. If this gives no response, the interrupter should be vigorously manipulated and contacts made with several locations on the tooth before the rheostat is advanced. Contact with metal restorations should be avoided, because of the possibility of the current being carried through them to the gums or adjacent teeth. Extensive experience and unprejudiced observation lead to the conclusion that while being useful adjuncts, vitality tests and transillumination cannot be depended upon in locating pulpless or septic teeth.

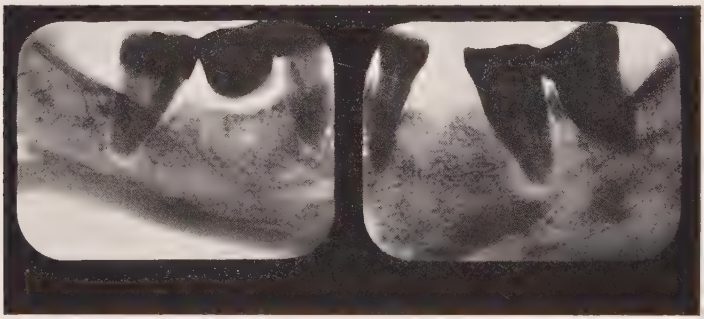


Fig. 29.—Examples of septic teeth which respond to vitality tests. These teeth with definite periapical involvement contained putrescent pulps which were still sensitive to electricity, thermal shock, and instrumentation. It may also be observed that these are not multirooted teeth.

Case Records.—Elaborate history charts are not essential for efficient radiodontic service, but the notation of clinical findings which supplement or modify the radiographic evidence, is valuable in subsequent consideration of the case and accumulating statistics.

The clinical inspection, vitality tests, and history often have an important bearing on the diagnosis, and these data should be concisely recorded rather than entrusted to memory. The listing and indexing of anomalies and unusual pathologic manifestations, enables one to find

suitable examples for study and illustration when desired.

Duplicate negatives should be preserved and carefully filed under the patient's name for ready inspection, should the occasion arise. Radiographic records are not only valuable for diagnosis, treatment, and scientific investigation, but may prove agencies of justice to operators accused of error or malpractice. The radiographic negatives are the records of the examination and the property of the examiner, who should retain them for the inspection of any one connected with the case. In referred cases, one set of negatives should be delivered to the dentist or physician who requested the examination, but the patient has no more justification in demanding possession of these records than of laboratory specimens.

CHAPTER IV

INTRAORAL REGIONS IN DETAIL

Maxillary Incisor Region

Position of Head. Occlusal plane of maxillary teeth horizontal.

Vertico-horizontal Angle of Projection { Median view, average 38 degrees. Diagonal views, average 38 degrees.

Modifications. Forty degrees or greater where there is a marked labial inclination of the teeth, or the roots are unusually long. Thirty-five degrees or less as the teeth approach a vertical position, or the roots are exceptionally short.

Mesio-distal Angle of Projection { Median view directly between the central incisors. Diagonal views directly between the central and lateral incisors.

Modifications. Compensation for a deflected nasal septum, or a marked mesio-distal inclination of the teeth.

Placement of Film Packet. Median view. Longer dimension vertically. Upper corners slightly bent. Place packet to include the lateral incisors equally, or equal portions of each cuspid; incisally to include the incisal edges of the teeth in symmetrical relation to the end of the packet at the predetermined angle of projection. Diagonal views. Longer dimension vertically. Upper mesial corner bent. Place packet mesially to include three-fourths of the opposite central incisor and distally to the width of the packet; incisally about 3 mm. below the incisal edge of the central incisor, and 6 mm. below the cusp of the cuspid.

Retention of Packet. Median view, patient's right thumb on the center of the upper half of the packet. Left diagonal view, patient's right thumb on the upper mesial quarter of the packet. Right diagonal view, patient's left thumb on the upper mesial quarter of the packet. Fingers of retaining hand rested on the temporal region.

Cone. Median view, centered midway the central incisor roots. Diagonal views, centered midway the lateral incisor root.

Spark Gap. 4 to 4½ inches, or 60 to 66 kilovolts.

Exposure. 110 to 150 milliampere seconds for median view, 90 to 120 milliampere seconds for diagonal views at an 18 inch target-film distance. (Note: Refer to p. 63 for the factors which modify exposure.)

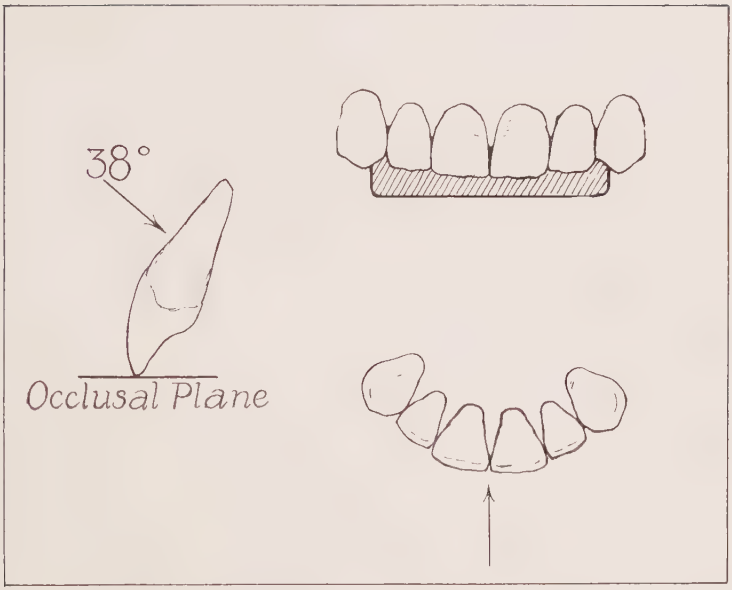


Fig. 30.—Diagrams of the position of the film packet, and the average angles of projection for a median view of the maxillary incisor region.

Fig. 31.—Position of the film packet and retaining hand for median view of maxillary incisor region.

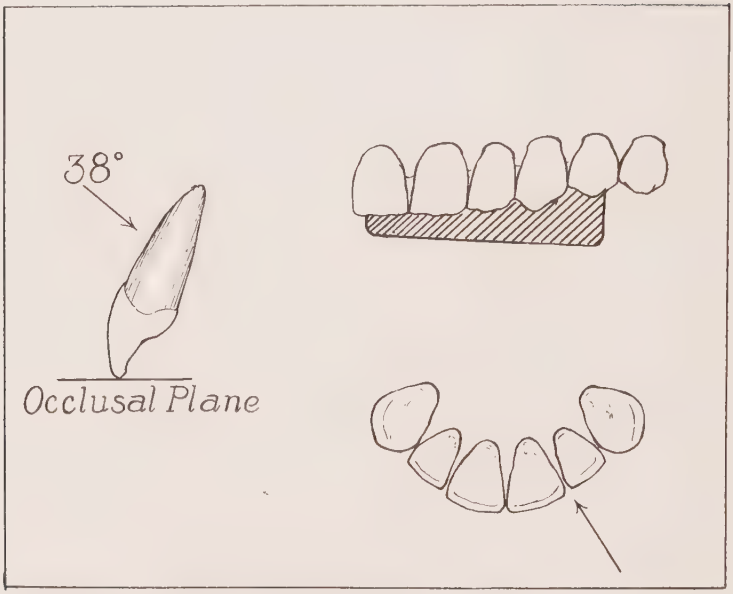


Fig. 32.—Diagrams of the position of the film packet, and the average angles of projection for a diagonal view of the maxillary incisor region.

Fig. 33.—Position of film packet and retaining hand for right diagonal view of the maxillary incisor region.

Fig. 34.—Illustration of correct pose with the lip covering the teeth and the average position of the cone for the maxillary incisor region.

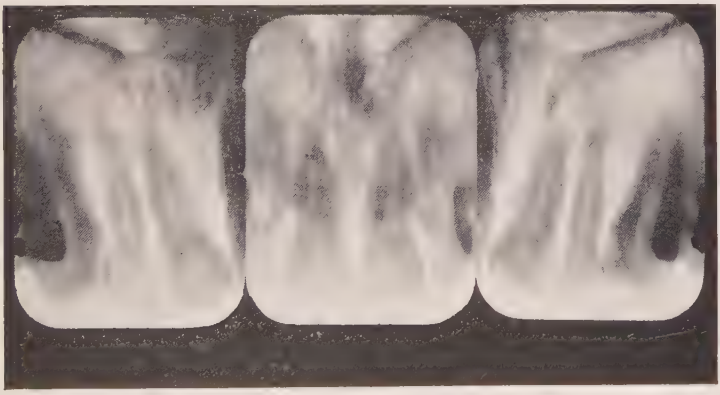


Fig. 35.—The three routine views of the maxillary incisor region to exclude confusing anatomic structures and distortion from curvature of the arch.

Explanatory Description.—More confusing extraneous structures are superimposed in the maxillary incisor region than any other of an intraoral examination. To

exclude these structures in accurately determining conditions, and to compensate for the curve in the dental arch, three routine views of the region are required. This quota should not be reduced because the teeth appear

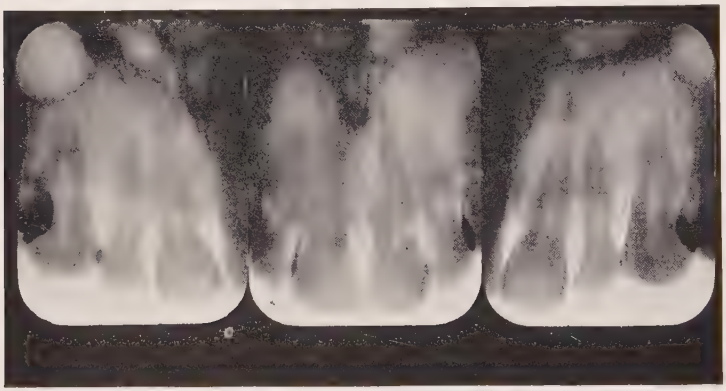


Fig. 36.—A deflected nasal septum which obscures the left central incisor and produces a difference in the radiolucence of the nostrils.

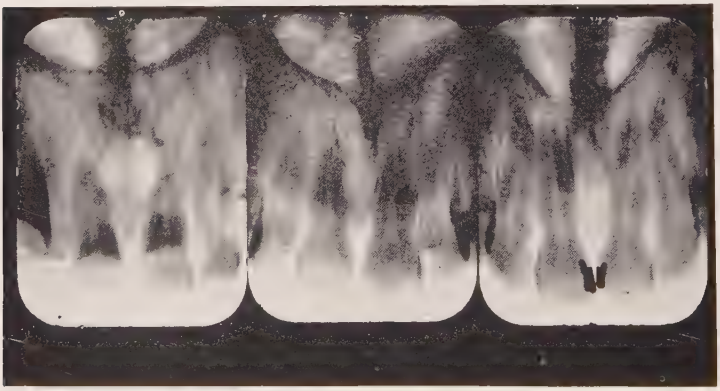


Fig. 37.—Three distinctive types of incisive foramina. The one on the right is characteristic in form, but slightly larger than the average.

normal. Contrary to the legal assumption regarding the burden of proof, in a radiodontic examination all regions should be suspected until proved innocent.

In the median view of the four incisors which has gen-

erally been considered sufficient, the following anatomic perplexities are registered: 1. The soft tissue of the nose, producing an increased radiopacity over the apical area and ending with a curved line of demarcation usually about midway of the roots. 2. The nasal spine and septum producing a marked radiopacity between and above the central incisors, a deflected septum often obscuring the root of one central incisor. 3. The nostrils, registering radiolucent areas near the apices of the central incisors. 4. The incisive foramen forming an oval radiolucent area between the roots of the central incisors. 5.

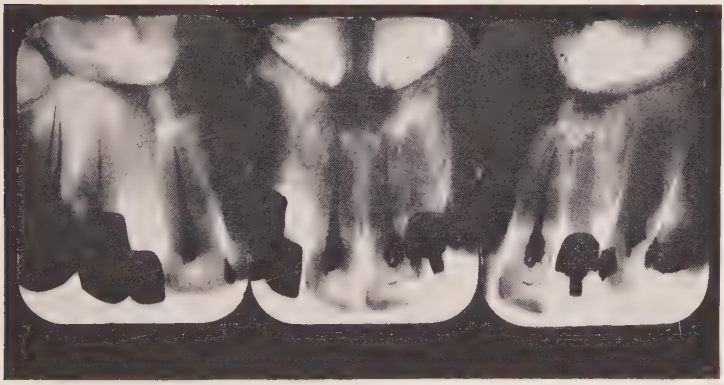


Fig. 38.—The nasal spine and septum obscuring in the median view a periapical involvement of each central incisor, which is disclosed in the diagonal views.

The incisive fossae, producing a diffuse radiolucence around the lateral incisor roots.

In the diagonal views the nasal structures are projected away from the side radiographed, but the incisive foramen may be registered near the apex of the central incisor or the ala be superimposed on the apical third of the lateral incisor root.

The form of the nose should be studied in calculating the angle of projection, that the denser portions, espe-

cially the septum, will not obscure important areas in the negative. The size of the nose should be considered in reckoning the exposure time, as a variance of 30 per cent is required for the extreme types.

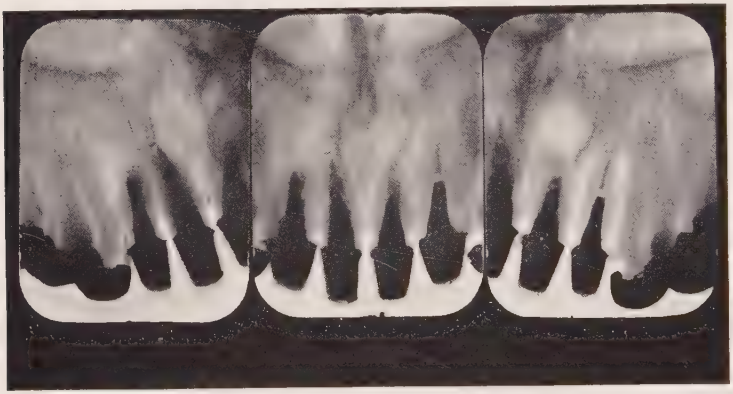


Fig. 39.—An unusual formation of the incisive foramen, which might be mistaken for pathologic destruction.

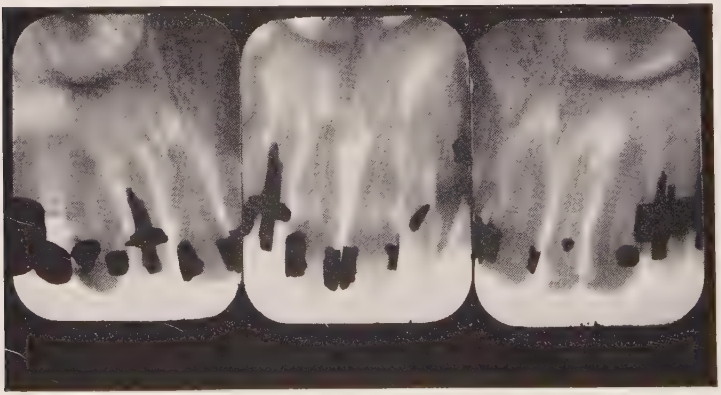


Fig. 40.—The incisive foramen superimposed on the right central incisor in the diagonal view, as demonstrated in Fig. 41. The left central incisor contained a septic pulp, and the bone involvement can be distinguished in all the views. A perforation of the left lateral incisor root is disclosed in the diagonal view.

Before the exposure is made, the patient should be requested to draw the lip over the teeth. The words "down," "lower," or "drop," should not be used in this

request, because the suggestion often causes a simultaneous movement of the head. When there is a hesitancy in complying with the request, the operator may gently

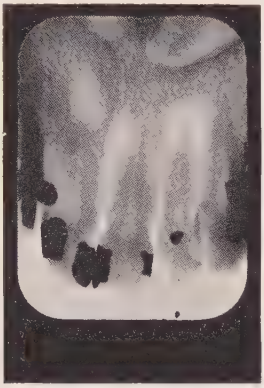


Fig. 41.—A modified diagonal view of the case in Fig. 40 to project the incisive foramen away from the right central incisor, the pulp of which is vital.

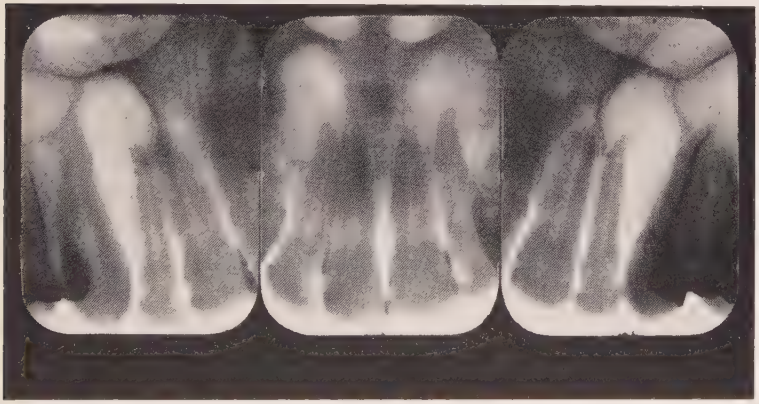


Fig. 42.—Remarkably similar cystic involvement of the lateral incisors, which in the median view might be mistaken for the radiolucence of the nostrils.

draw the lip over the teeth. The covering of the tooth crowns by the lip increases the absorption of the rays, and to a degree equalizes the greater radiolucence of the thin crowns as compared with the other structures.

Maxillary Cuspid Region

Position of Head. Occlusal plane of maxillary teeth horizontal.

Vertico-horizontal Angle of Projection. Average 40 degrees.

Modifications. Forty-two degrees or greater where there is a marked labial inclination of the cuspid, or the root is exceptionally long. Thirty-eight degrees or less as the cuspid approaches a vertical position, or where the root is exceptionally short.

Mesio-distal Angle of Projection. Perpendicular to the labial ridge of the cuspid.

Modifications. Slightly mesially or distally if the cuspid is rotated, when there is a marked mesial inclination of the teeth, or to disclose both roots of the first bicuspid.

Placement of Film Packet. Longer dimension vertically. Upper mesial corner bent. Place mesial side to include the root of the lateral incisor, which will include the crown except where there is a marked inclination of the teeth. Place incisal end to include the cusps of the teeth in symmetrical relation to the end of the packet at the predetermined angle of projection, which requires the distal corner to be lower than the mesial to compensate for the greater bucco-lingual diameter of the bicuspids than the cuspid and lateral incisor.

Retention of Packet. Thumb of patient's opposite hand placed nearer the upper mesial corner to closely adapt the packet and minimize the area of distortion.

Cone. Centered midway the cuspid root.

Spark Gap. 4 to 4½ inches, or 60 to 66 kilovolts.

Exposure. 90 to 120 milliampere seconds at an 18 inch target-film distance.

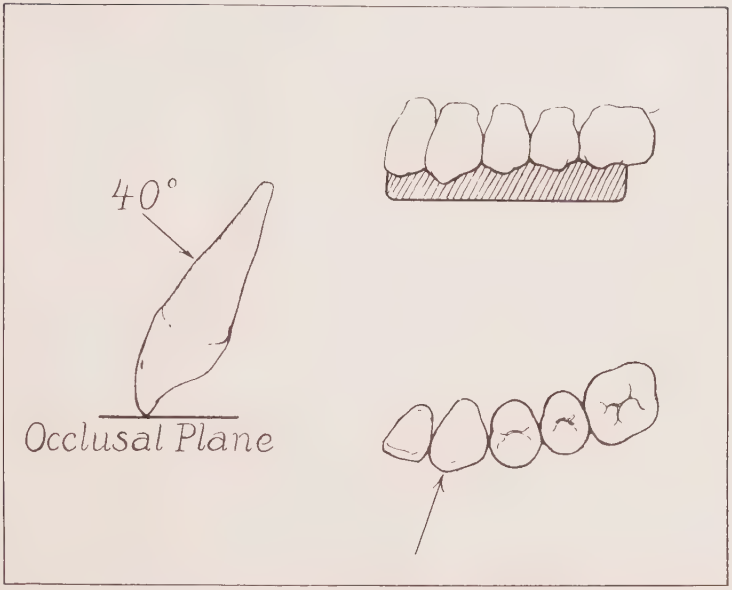


Fig. 43.—Diagrams of the position of the film packet, and the average angles of projection for examination of the maxillary cuspid region.

Fig. 44.—Position of the film packet and retaining hand for the maxillary cuspid region. The contraction of the muscles to expose the teeth has produced a heavy fold of tissue above the angle of the mouth.

Fig. 45.—Levator muscles relaxed permitting the lip to cover the teeth, and eliminating the fold of tissue shown in Fig. 44.

Fig. 46.—Position of patient and cone for exposure of the maxillary cuspid region.

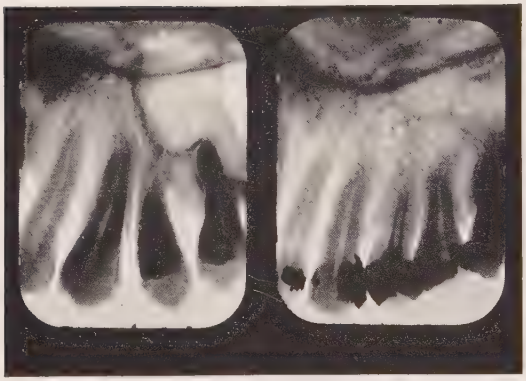


Fig. 47.—Typical views of the maxillary cuspid region, disclosing the lateral incisor and the roots of the first bicuspid separately. In the right illustration, the crown of the lateral incisor is only partially included to void excessive distortion in the upper mesial corner.

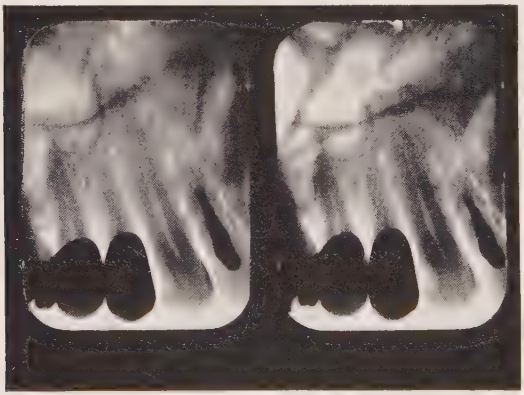


Fig. 48.—An illustration of the difference in distortion and root length in the image by a change of only 5 degrees in the vertico-horizontal angle of projection.

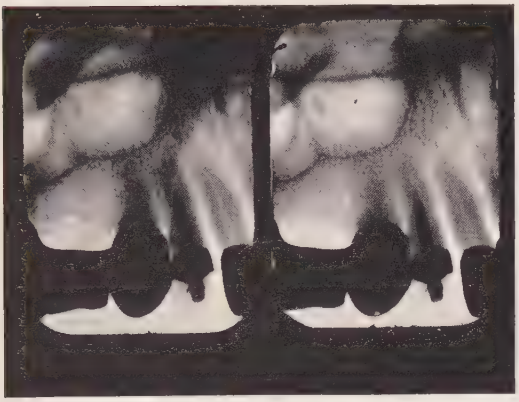


Fig. 49.—An illustration of the line of demarcation produced by contraction of the levator muscles, and the improvement from eliminating the confusing shadow. The incisor portion of this region is more radiolucent than the remainder of the alveolar process without exaggerating the contrast

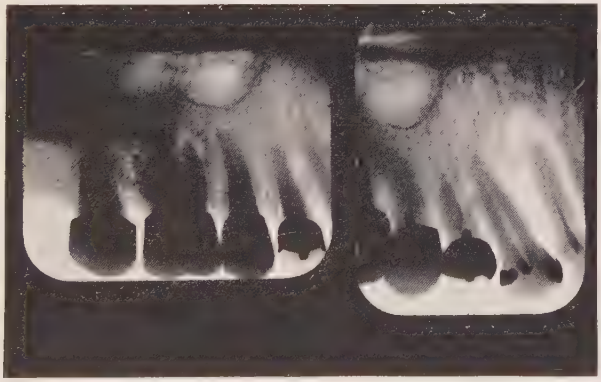


Fig. 50.—A perforation between the roots of a first bicuspid, which is disclosed by the diagonal view. The roots of the first bicuspid are usually superimposed when viewed with the first molar.

Explanatory Description.—One view is allotted to the maxillary cuspid, because the length of the root and the curve of the arch at that point prevent including it in a normal view of the incisors or bicuspids. However, in the examination of the cuspid region, a diagonal view of the lateral incisor and bicuspids may be obtained to disclose additional information on the incisor region, and the separate roots or canals of the first bicuspid.

The maxillary cuspid region presents little technical or anatomic difficulty excepting the calculation required to

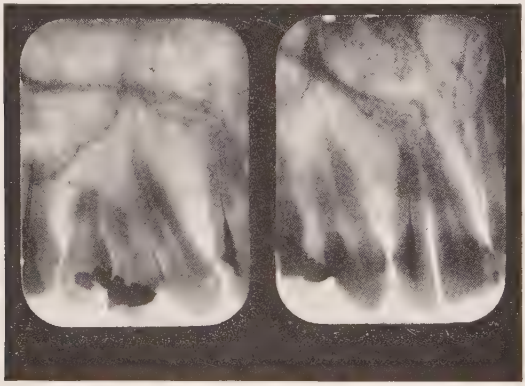


Fig. 51.—A case in which the divergence of the lateral incisor and cuspid roots prevents showing them to the best advantage in the same view.

record the approximate length of the root without an excessively large area of distortion in the negative. The apex of the root is usually so near the level of the vault that there is slight latitude in the vertico-horizontal angle of projection without producing a foreshortening or distorted elongation. In calculating the mesio-distal angle to record the roots of the first bicuspid separately, the position of the tooth should be studied from the occlusal and buccal surfaces. When the bicuspid is rotated, the mesio-distal angle should be modified to approach a perpendicular to a point midway between the buccal ridge

and the mesio-buccal angle. When the buccal surface is rotated toward the mesial, it is often possible to disclose the roots separately in the view of the bicuspids with the first molar region.

Before the exposure, the patient should be requested to relax the lip to cover the teeth and equalize the soft tissue absorption of the rays. While examining the teeth and placing the packet in the cuspid region, there is a tendency for the patient to lift the lip and angle of the mouth by a vigorous contraction of the levator muscles. This produces a fold of tissue one-half an inch or more in thickness extending upward and forward from the angle, with a resultant diagonal line of demarcation in the negative. Since the incisor portion of this region is more radiolucent than the bicuspid, when the contrast is exaggerated by muscle contraction it may cause an incorrect diagnosis of pathologic destruction in the incisor area or fracture of the cuspid root. To eliminate the objectionable shadow it is often necessary to request the patient to contract the lips as though to whistle, and when adipose deposits are heavy or the muscles and lines of expression are strongly developed, this difficulty cannot entirely be overcome.

Maxillary First Molar Region

Position of Head. Occlusal plane of maxillary teeth horizontal.

Vertico-horizontal Angle of Projection. Average 30 degrees.
Modifications. Thirty-two degrees or more where there is a marked buccal inclination of the teeth, or the roots are unusually long. Twenty-eight degrees or less as the teeth approach a vertical position, or the roots are exceptionally short.

Mesio-distal Angle of Projection. Parallel with the mesial surface of the first molar in its normal position.
Modifications. Compensation for a marked rotation of the first molar, or to avoid the malar process.

Placement of Film Packet. Longer dimension horizontally. Upper mesial corner slightly bent. Place packet to include the distal half of the cuspid, and extend distally to the length of the packet; occlusally to include the cusps of the teeth in symmetrical relation to the side of the packet at the predetermined angle of projection.

Retention of Packet. Thumb of patient's opposite hand placed on the center of the upper third of the packet. Fingers of the retaining hand rested on the temporal region.

Cone. Centered midway the second bicuspid root.

Spark Gap. 4 to 4½ inches, or 60 to 66 kilovolts.

Exposure. 120 to 160 milliampere seconds at an 18 inch target-film distance.

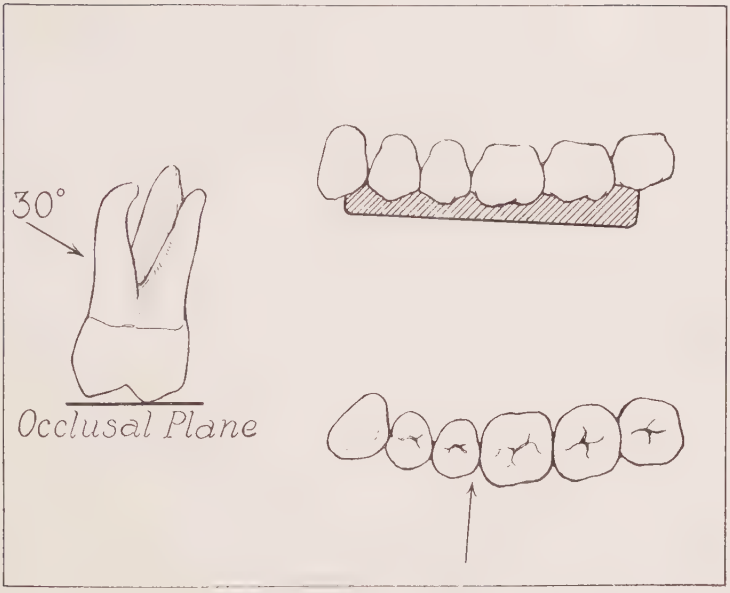


Fig. 52.—Diagrams of the position of the film packet, and the average angles of projection for examination of the maxillary first molar region.

Fig. 53.—Position of film packet and retaining hand for the maxillary first molar region.

Explanatory Description.—The principal difficulties encountered in the examination of the maxillary first molar region are the proximity of the malar process, and the complications from the three divergent roots of the first molar. The bicuspids are included in this region because the angle of projection for a linguo-buccal view of them approximates that of the first molar. Although the sec-

Fig. 54.—Position of patient and cone for the maxillary first molar region.

ond and third molar is disregarded in this view, supplemental information on the region is often obtained. The three molars cannot be included to advantage in examination because of the variance in direction of the bucco-lingual axes, and the obstruction of the malar process and malar bone.

In calculating the vertico-horizontal angle of projection, a compromise between an accurate image of the buccal roots and the lingual root of the first molar must

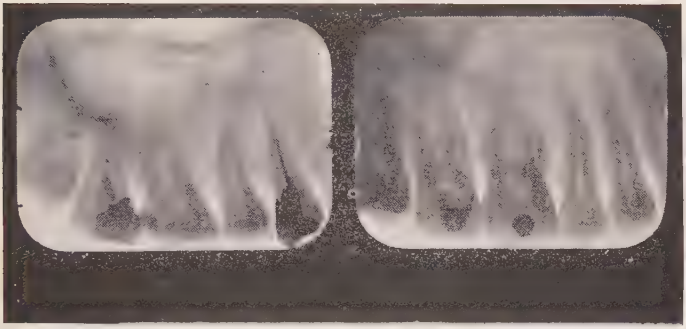


Fig. 55—Typical views of the maxillary first molar region disclosing the apices of disto-buccal and lingual roots by the mesio-distal angle of projection paralleling the mesial surface.

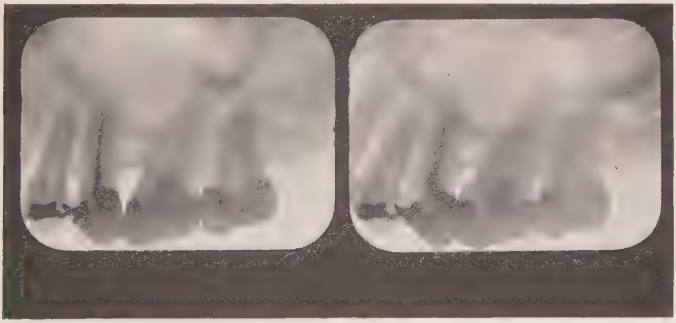


Fig. 56.—An illustration of the malar process obscuring the lingual root of the first molar at the usual mesio-distal angle, and the distortion of the buccal roots in revealing the lingual root.

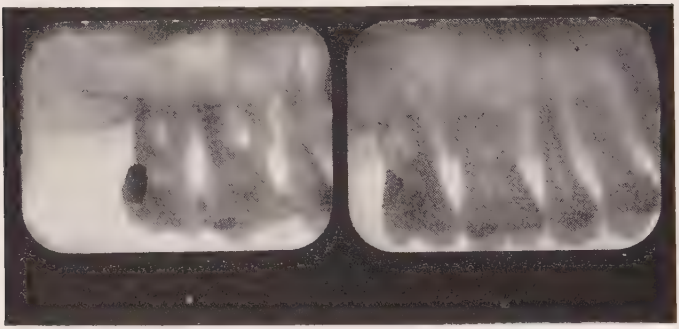


Fig. 57.—Illustrating the projection of the mesio-buccal root of the first molar for view in examination of the second and third molar region, while the disto-buccal and lingual roots are disclosed in the first molar examination.

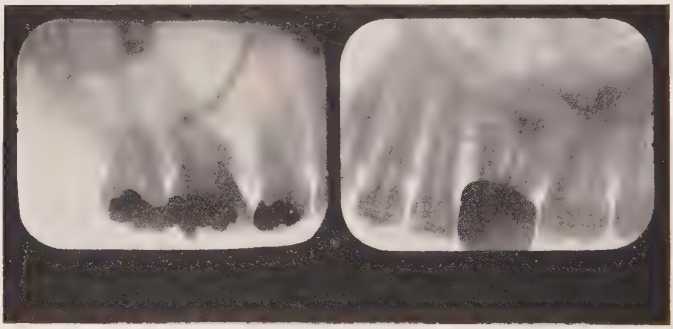


Fig. 58.—Illustrations of unfavorable views at the normal angle of projection because of marked root divergence.

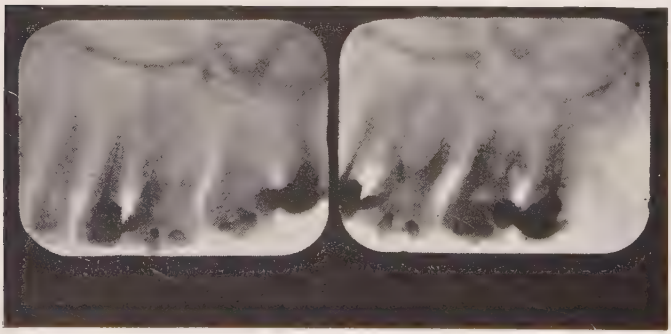


Fig. 59.—Illustrating the radiolucence around the buccal roots of the first molar when they are projected beyond the lingual root.

be accepted since the roots lie in different planes. The desirable mean angle will record the approximate root length of the bicuspids, foreshorten the image of the buccal roots of the first molar, and elongate the image of the lingual root. Where extreme divergence of the roots occurs, separate views may be required for the buccal and the lingual roots.

The mesio-distal angle recommended for the first molar region discloses approximal caries, and inter-proximal conditions from the distal surface of the cuspid to the mesial surface of the second molar. It projects the roots of the first molar symmetrically grouped with the mesio-buccal superimposed, but the apices of the lingual and distobuccal roots unobstructed. The mesio-buccal root is usually projected for a more favorable view in the examination of the second and third molar region. Caution must be exercised in determining conditions around the buccal roots of the first molar when they are projected beyond the superimposed portion, as the greater radiolucence of the periapical structures are likely to be misleading.

In a considerable proportion of subjects the malar process obstructs the most desirable view of the first molar, and it is necessary to project the lingual root separately by directing the rays more nearly perpendicular to the mesio-buccal angle of the tooth. This distorts the image of the buccal roots which require another view at the usual mesio-distal angle but a vertico-horizontal angle of about 10 degrees less than that for the lingual root. The great variation in the relation of the first molar roots, often requires further examination of the region after the negative produced at the normal angle of projection has been examined. If the angle for each exposure is closely observed, the corrections to give additional information can be accurately made.

Maxillary Second Molar Region

Position of Head. Occlusal plane of maxillary teeth horizontal.

Vertico-horizontal Angle of Projection. Average 20 degrees.
Modifications. Twenty-five degrees or more where there is a marked buccal inclination of the teeth, or the roots are unusually long. Eighteen degrees or less as the teeth approach a vertical position, or the roots are exceptionally short.

Mesio-distal Angle of Projection. Perpendicular to the median line, or the buccal surface of the second molar.
Modifications. Direct the rays from a more posterior point when the interproximal space permits, or the teeth are isolated.

Placement of Film Packet. Longer dimension horizontally. Upper one-fifth sharply bent throughout the entire length. Place packet to include the tuberosity and extend mesially to the length of the packet; occlusally to include the cusps of the teeth in symmetrical relation to the side of the packet at the predetermined angle of projection. After the patient's retaining thumb is placed, push upward and inward on the lower portion of the packet to closely adapt it to the curve of the vault and approximate the lower four-fifths to a vertical plane.

Retention of Packet. Thumb of patient's opposite hand placed on the center of the bent upper one-fifth of the packet. Fingers of the retaining hand rested on the temporal region.

Cone. Centered midway the second molar roots.

Spark Gap. 4½ to 5 inches, or 66 to 72 kilovolts.

Exposure. 160 to 200 milliampere seconds at an 18 inch target-film distance.

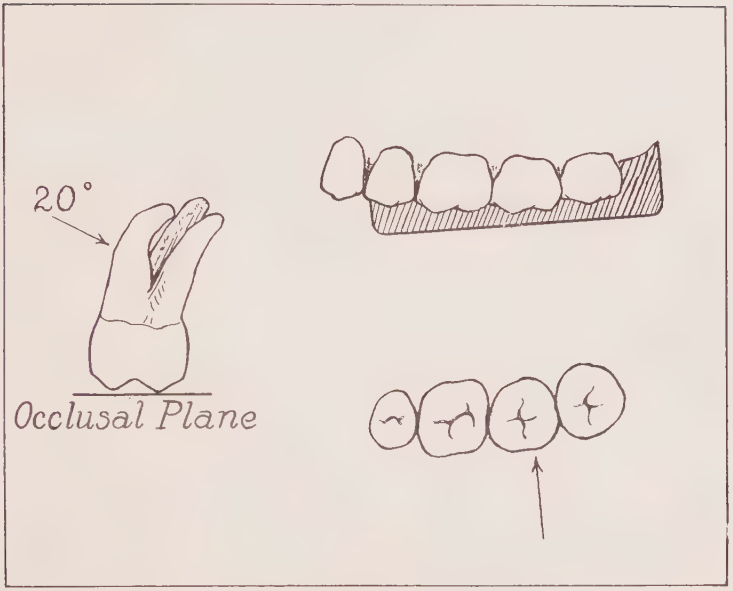


Fig. 60.—Diagrams of the position of the film packet, and the average angles of projection for examination of the maxillary second molar region.

Fig. 61.—Position of film packet and retaining hand for the maxillary second molar region.

Fig. 62.—Position of patient and cone for the maxillary second molar region.

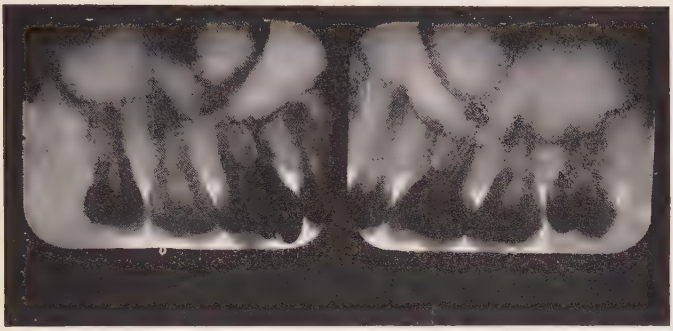


Fig. 63.—Typical views of the maxillary second molar region where the malar process and malar bone are superimposed on the roots of the teeth.

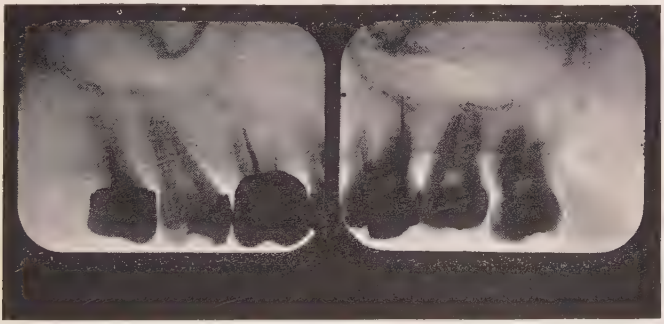


Fig. 64.—Typical views of the maxillary second molar region where it is possible to project the malar process and malar bone above the roots of the teeth.

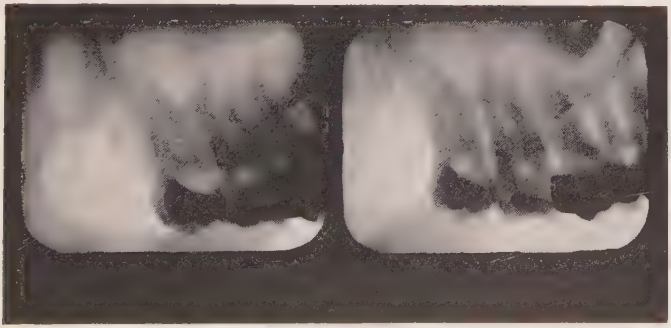


Fig. 65.—An illustration of the teeth being superimposed by the rays having been directed from a point too far posteriorly, and the result of correcting the mesio-distal angle of projection. The image of the coronoid process may be seen superimposed on the tooth crowns by having the mandible lowered.

Explanatory Description.—The maxillary second molar region presents the greatest difficulty in examination of any region in either arch, because of the proximity of the malar process and malar bone. Where the length or position of the teeth necessitates a vertico-horizontal angle of more than 20 degrees, the malar bone is usually superimposed near the apices. Since the lower border of the malar bone curves upward and backward from the malar process, it is advisable to direct the rays from a point as far posteriorly as practicable. With an isolated second or third molar it is usually possible to direct the rays under the malar bone from the posterior, but with molars in contact the superimposition of the teeth limits the latitude of the mesio-distal angle. When the malar process obscures the second molar region at the normal angle of projection, it is sometimes possible to obtain a better view from a more anterior position of the tube, directing the rays almost perpendicular to the mesio-buccal angle of the second molar. Occasionally it is possible to project the image of the malar process well below the apices of the second molar roots, and this possibility should be remembered when the conditions are presented.

It is usually desirable to project the image of the malar structures above the teeth, hence the position of the teeth and the preceding radiograph of the first molar region should be studied in calculating the lowest angle of projection which is feasible. Most operators use a higher angle than necessary for the second molar region, and often a surprisingly low angle of projection is permissible.

In calculating the vertico-horizontal angle, one must consider that there is elongation of the second molar roots in the radiograph of the first molar region due to the mesio-distal angle of projection and the distal inclination of the roots. The mesio-distal angle which is ap-

plied to the second molar region compensates for distal inclination of the roots and shortens the image of them. Therefore, it is advisable to be rather daring in reducing the vertico-horizontal angle for the initial exposure of this region. When it is found impossible to project the malar images above the teeth, it becomes necessary to modify both the vertico-horizontal and mesio-distal angles for a diagnostic view of the region with the minimum sacrifice of perspective.

The superimposition of the coronoid process of the mandible should be considered in the examination of this region, although its relative location cannot be definitely foretold. At the higher vertico-horizontal angles of projection, the opening of the patient's mouth to the limit of the articulation will usually carry the coronoid process sufficiently low to project it below the teeth. At the lower angles, favorable conditions will more frequently be obtained by having the patient close the teeth against the retaining thumb to move the coronoid process above and back of the tuberosity. When the objectionable superimposition is not excluded by either of these positions and the necessary cooperation is obtainable, having the patient slowly raise and lower the mandible during the exposure will diffuse the image of the coronoid process so it will not obscure the other structures.

The sharp bending of the packet for retention of the upper one-fifth against the vault, while the remainder approximates a vertical plane, gives a more favorable surface for recording the image than the convexity produced by retaining the packet near the center. Insufficient penetration and exposure is a common mistake in the examination of this region. A longer exposure may not compensate for the structures encountered, hence the increase in penetration which is recommended.

Mandibular Incisor Region

Position of Head. Lateral. Incisal plane horizontal. Antero-posterior. Reclined sufficiently for the longitudinal axes of the mandibular incisors to be vertical when the mouth is open for the retention of the film packet.

Vertico-horizontal Angle of Projection. Fifteen degrees below horizontal.

Modifications. Twenty degrees below horizontal where the teeth are exceptionally long, or the packet cannot be adapted as usual.

Mesio-distal Angle of Projection. Directly through the interproximal space of the central incisors.

Modifications. Compensation for a marked mesio-distal inclination of the incisors, especially when the roots are divergent.

Placement of Film Packet. Longer dimension vertically. Lower corners slightly bent. Place packet to laterally include equal portions of the cuspids or first bicuspids, and incisally to include the incisal edges of the teeth in symmetrical relation to the end of the packet at the angle of projection. Important details regarding the placement of the packet are given in the explanatory description.

Retention of Packet. First finger of patient's right hand placed on the center of the lower third of the packet. Patient's thumb rested below the right molar region, and unemployed fingers flexed to avoid obstructing the field. This position is obtained by raising the patient's right arm until the elbow is level with the shoulder, and then placing the retaining hand in the position described.

Cone. Centered midway the central incisor roots.

Spark Gap. 4 to 4½ inches, or 60 to 66 kilovolts.

Exposure. 90 to 120 milliampere seconds at an 18 inch target-film distance.

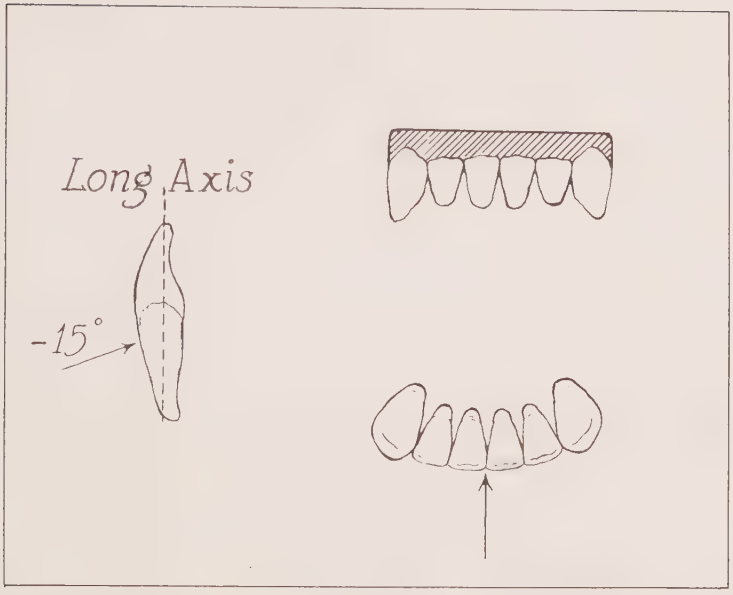


Fig. 66.—Diagrams of the position of the film packet, and the average angles of projection for examination of the mandibular incisor region.

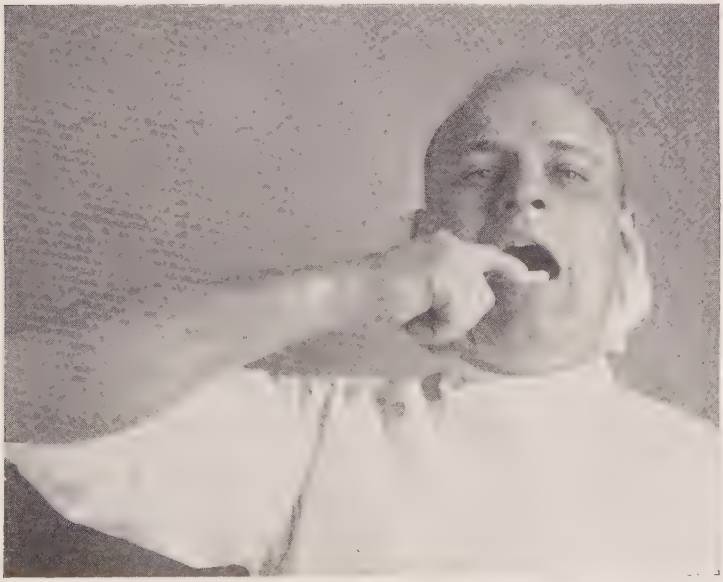


Fig. 67.—Position of film packet and retaining hand for the mandibular incisor region.

Explanatory Description.—The principal difficulty encountered in examination of mandibular incisor region is the satisfactory placement and retention of the film packet, with the accompanying discomfort to the patient. The pain caused in placing the film packet can to a great degree be avoided by careful manipulation. The customary method of sliding the packet directly downward

Fig. 68—Position of patient and cone for mandibular incisor region.

as far as the patient will endure is unnecessarily painful, and not conducive to the most advantageous placement. In this method the lower edge of the packet is forcibly slid over the attachment of the frenum and muscles, with little opportunity for the tissues to adapt themselves to the unusual intrusion.

The placement of the packet is facilitated by employing three adapting movements. (1) Place the lower third of the packet on the lingual surfaces of the teeth, and adapt

it to the curve of the arch. (2) Lift the packet and place the lower two-thirds on the teeth and gingiva with adapting pressure. (3) With the packet removed from contact with the tissues direct it downward and backward under

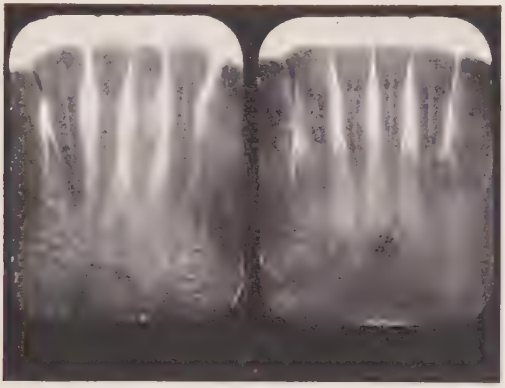


Fig. 69.—Typical views of the mandibular incisor region. Observe the marginal destruction which would not be accurately shown in a foreshortened view.

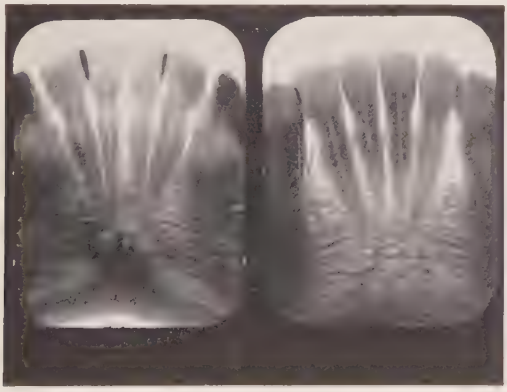


Fig. 70.—Mandibular incisors with convergent roots which are easily examined.

the tongue where it meets with little resistance until the upper edge is the desired relation to the incisal edges of the teeth. Then with the adapting finger placed well below the center of the packet, gently but firmly press it

to place. This method gradually conforms the packet in advance, and when the pressure is applied for the final adaptation the packet is in a position to displace the soft tissues with the minimum tension.

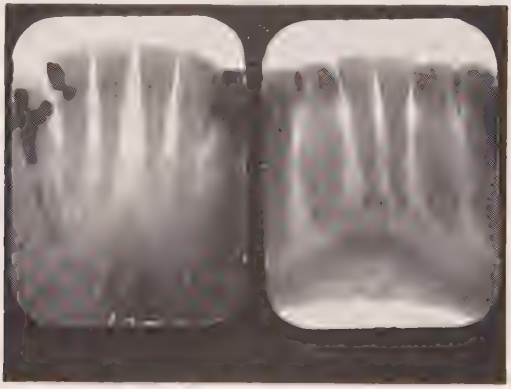


Fig. 71.—Mandibular incisors with roots divergent, which are difficult to reveal clearly in one view.

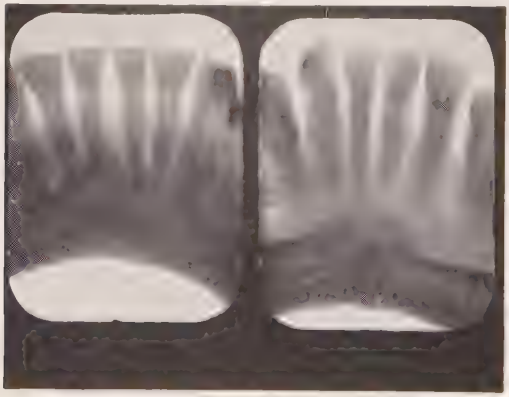


Fig. 72.—Mandibular incisor views in which the mental protuberance is superimposed on the apical area.

The retention of the packet and the obstruction by the patient's fingers usually present exasperating difficulties in this region, which can be avoided by the position of the retaining hand and demonstrating the pressure re-

quired. In examination of all mandibular regions, the patient should be told that some unavoidable discomfort must be endured for the success of the operation, and the patient should be cautioned not to swallow during the exposure. The latter request should not be made until just before the exposure is begun, to reduce the period of perverse desire produced by the suggestion. The movement of the tongue in deglutition is most likely to displace the packet, so the effect of the warning justifies the suggestion which increases the desire.

In posing the patient's head so the longitudinal axes of the teeth are vertical, the convexity of the labial surfaces must be considered for the head must be further reclined to have the teeth vertical than just the labial surfaces vertical. Malposition of the mandibular incisors is common, and the mesio-distal inclination of the roots should be calculated in choosing the mesio-distal angle of projection. When an extremely narrow arch or a marked divergence of the roots will produce a distortion of the lateral incisor images, these teeth may be better viewed in the examination of the cuspid regions.

Because of the size of the mandibular incisors and the thin alveolar process in this region, operators are prone to reduce the exposure to less than the adequate requirement. Since the mental protuberance may be superimposed near the apical region the exposure should be sufficient to penetrate the entire region although the thinner portions may be overexposed.

Mandibular Cuspid Region

Position of Head. Lateral. Occlusal plane horizontal. Antero-posterior. Reclined sufficiently for the longitudinal axis of the cuspid to be vertical when the mouth is open for the retention of the film packet.

Vertico-horizontal Angle of Projection. Fifteen degrees below horizontal.

Modifications. Twenty degrees below horizontal where the root is exceptionally long, or the film packet cannot be adapted as usual.

Mesio-distal Angle of Projection. Perpendicular to the labial ridge of the cuspid.

Modifications. Compensation for an extreme mesio-distal inclination of the cuspid.

Placement of Film Packet. Longer dimension vertically. Lower mesial corner slightly bent. Place packet to include the root of the lateral incisor, unless the incisor roots are markedly convergent, and to extend distally to the width of the packet; occlusally to include the cusps of the teeth in symmetrical relation to the end of the packet at the angle of projection.

Retention of Packet. First finger of patient's opposite hand placed near the lower mesial corner of the packet, thumb rested on the lower border of mandible below the opposite bicuspids, and unemployed fingers flexed.

Cone. Centered midway the first bicuspid root.

Spark Gap. 4 to 4½ inches, or 60 to 66 kilovolts.

Exposure. 90 to 120 milliampere seconds at an 18 inch target-film distance.

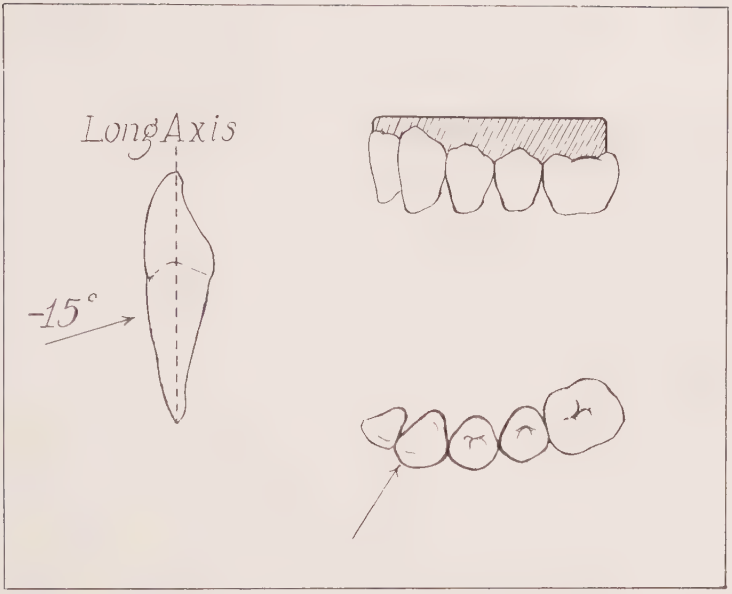


Fig. 73.—Diagrams of the position of the film packet, and the average angles of projection for examination of the mandibular cuspid region.

Fig. 74.—Position of film packet and retaining hand for the mandibular cuspid region.

Explanatory Description.—The placement and retention of the film packet with the discomfort involved, and the tendency to distortion of the image are the principal difficulties encountered in examination of the mandibular cuspid region. The length of the cuspid root and the sharp curve of the dental arch in this region prevent examination of the cuspid to the best advantage in the

Fig. 75.—Position of patient and cone for the mandibular cuspid region.

normal view of the incisors or bicuspids. However, in examination of the cuspid region, a diagonal view of the bicuspids and in some cases of the lateral incisor can be obtained. This diagonal view discloses the relative location of the mental foramen to the bicuspids, and when the roots of the incisors are divergent, it records the image of the lateral incisor more accurately than in the median view. When the incisor roots are convergent, only a por-

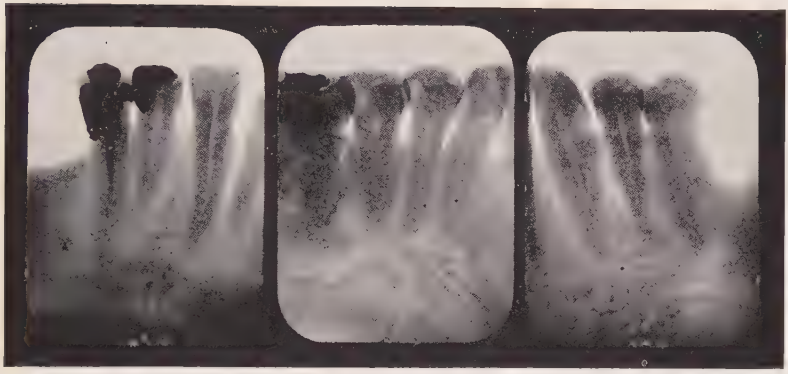


Fig. 76.—Typical views of the mandibular cuspid region.

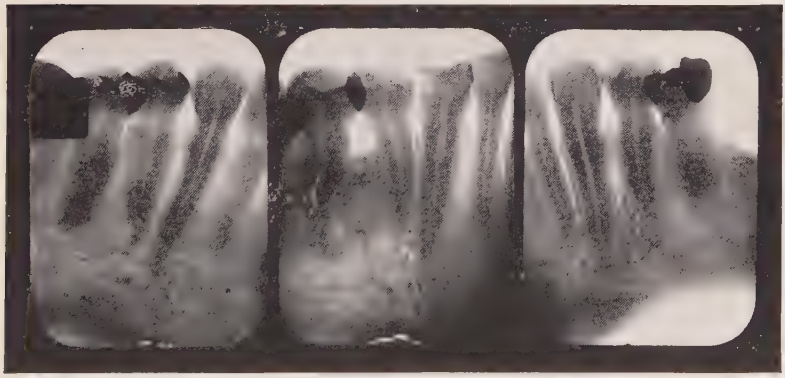


Fig. 77.—Views of the mandibular cuspid region where the roots are unusually long.

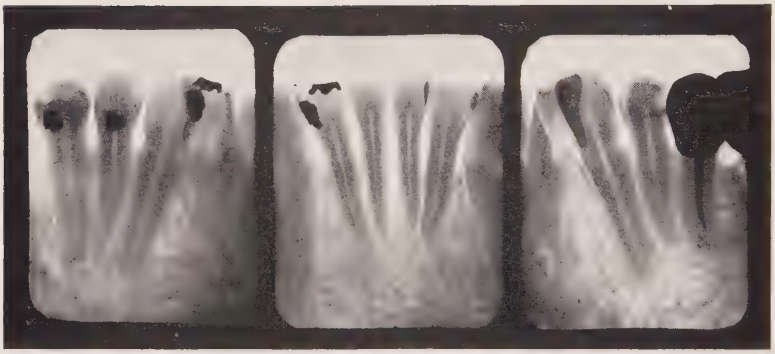


Fig. 78.—Views of convergent incisor roots illustrating the distortion resulting from an attempt to include the lateral incisors with the cuspid region under these conditions.

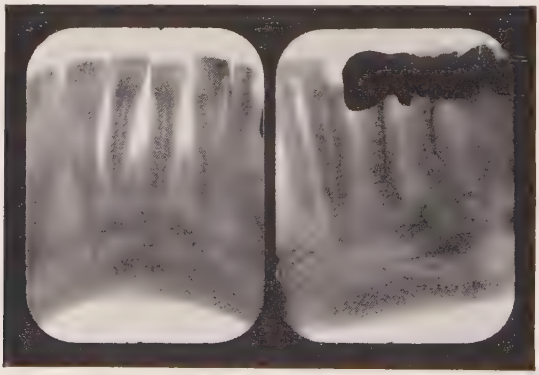


Fig. 79.—An illustration of divergent incisor roots where the lateral incisor can be examined more accurately with the cuspid region.

tion of the lateral incisor crown should be included with the cuspid to avoid excessive distortion of the image.

The marked bending of the film packet in the mesial third necessitates a compensatory direction in the mesio-distal angle of projection, and a common mistake is directing the rays from a point too far distally. Modifications of the mesio-distal angle of projection may be required for variance in the mesio-distal inclination of the cuspid, but this factor is corrected to a great degree by the pose recommended. Reclining the head to place

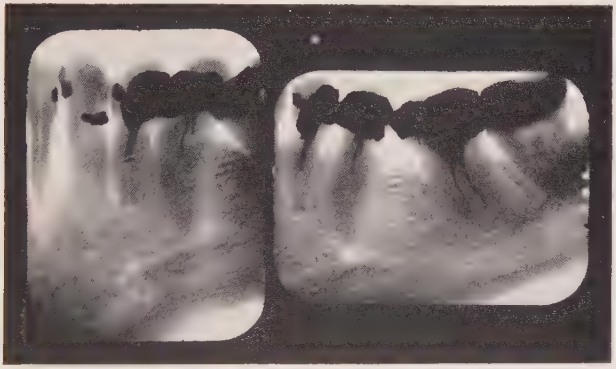


Fig. 80.—An example of the mental foramen being superimposed at the apex of a pulpless bicuspid in examination of the first molar region, and the diagnosis corrected by the diagonal view of the bicuspids in the cuspid region.

the longitudinal axis of the cuspid vertically for examination of this region will be found a distinct advantage over the poses generally suggested for examination of the mandibular teeth.

To project the images in symmetrical relation to the upper end of the films, the distal corner of the packet must be placed about 3 millimeters farther above the occlusal plane than the mesial corner, because of the greater bucco-lingual diameter of the bicuspids than the cuspid and lateral incisor.

Mandibular First Molar Region

Position of Head. Reclined sufficiently for the occlusal plane of the mandibular teeth to be horizontal when the film holder or retaining finger is in place.

Vertico-horizontal Angle of Projection. Ten degrees below horizontal.

Modifications. Fifteen degrees below horizontal where there is a marked buccal inclination of the teeth, or the roots are unusually long. Five degrees below horizontal where there is an abnormal lingual inclination of the teeth, or the roots are exceptionally short.

Mesio-distal Angle of Projection. Parallel with the mesial surface of the first molar in its normal position.

Modification. Compensation for a marked malposition of the teeth.

Placement of Film Packet. Longer dimension horizontal. Lower mesial corner slightly bent. Film holder attached at the center of the upper side. Place packet to include the distal half of the cuspid, and extend distally to the length of the packet; occlusally to include the cusps of the teeth in symmetrical relation to the side of the packet at the angle of projection.

Retention of Film Packet. Firm pressure of the teeth on film holder, or first finger of patient's opposite hand on the film holder or near the lower mesial corner of packet when the loss of teeth prevents biting on the film holder.

Cone. Centered midway the second bicuspid root.

Spark Gap. 4 to 4½ inches, or 60 to 66 kilovolts.

Exposure. 110 to 150 milliampere seconds at an 18 inch target-film distance.

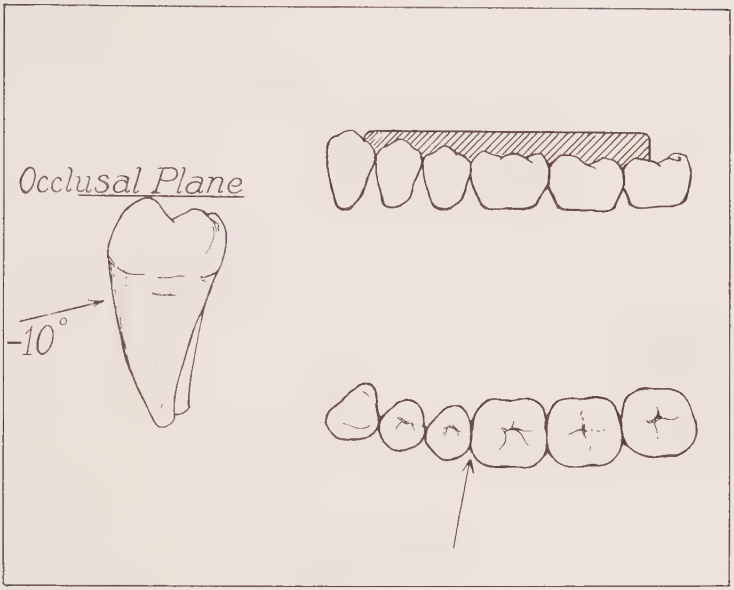


Fig. 81.—Diagrams of the position of the film packet, and the average angles of projection for examination of the mandibular first molar region.

Fig. 82.—Position of film packet and holder for the mandibular first molar region.

Explanatory Description. The mandibular first molar region generally presents the least difficulty of any in an intraoral examination. The plane of the film packet is

Fig. 83.—Position of patient and cone for the mandibular first molar region.

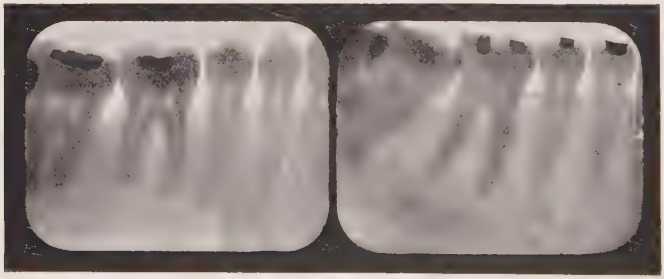


Fig. 84.—Typical views of the mandibular first molar region.

approximately parallel with that of the teeth, making the angle of projection especially constant. Where conditions permit, the use of film holder eliminates most of the difficulty in placing and retaining the packet.

It is desirable to examine the first molar exclusive of the second and third, because the bucco-lingual axes of the three molars are normally not parallel and they cannot be viewed to the best advantage with a common mesio-distal angle of projection. The most satisfactory view of the first molar is obtained by a mesio-distal angle

Fig. 85.—A case in which conditions permit a view of the second molar in examination of the first molar region, and another in which the second molar is only partially shown.

Fig. 86.—A set of universal film holders designed by Dr. Raper, which are especially indicated in the examination of mandibular molar regions.

Fig. 87.—Ordinary wood film holders, the upper surfaces of which have been sawed diagonally better to conform to the bite in examination of the mandibular molar regions.

of projection parallel with the mesial surface of the tooth, which discloses the lamina dura, the contour of the proximal surfaces, the pulp chamber, and both roots. This is also the normal view of the bicuspids which are included, and supplies some information about the second molar by a diagonal view of that tooth.

Mandibular Second Molar Region

Position of Head. Reclined sufficiently for the occlusal plane of the mandibular teeth to be horizontal when the film holder or retaining finger is in place.

Vertico-horizontal Angle of Projection. Horizontal.
Modifications. Five degrees or more below horizontal where the teeth approach a vertical position, or the roots are unusually long. Five degrees or more above horizontal as the teeth are lingually inclined.

Mesio-distal Angle of Projection. Perpendicular to the buccal surface of the second molar.
Modification. Compensation for malposition in the second or third molar.

Placement of Film packet. Longer dimension horizontal. Film holder attached near the middle of the upper side. Place packet to fully include the third molar region and extend mesially to the length of the packet; occlusally to include the cusps of the teeth in symmetrical relation to the side of the packet at the predetermined angle of projection.

Retention of Film Packet. Firm pressure of the teeth on the film holder, or first finger of patient's opposite hand on the film holder or just below the center of the packet when the loss of teeth prevents biting on the film holder.

Cone. Centered midway the distal root of the second molar.

Spark Gap. 4 to 4½ inches, or 60 to 66 kilovolts.

Exposure. 120 to 160 milliampere seconds at an 18 inch target-film distance.

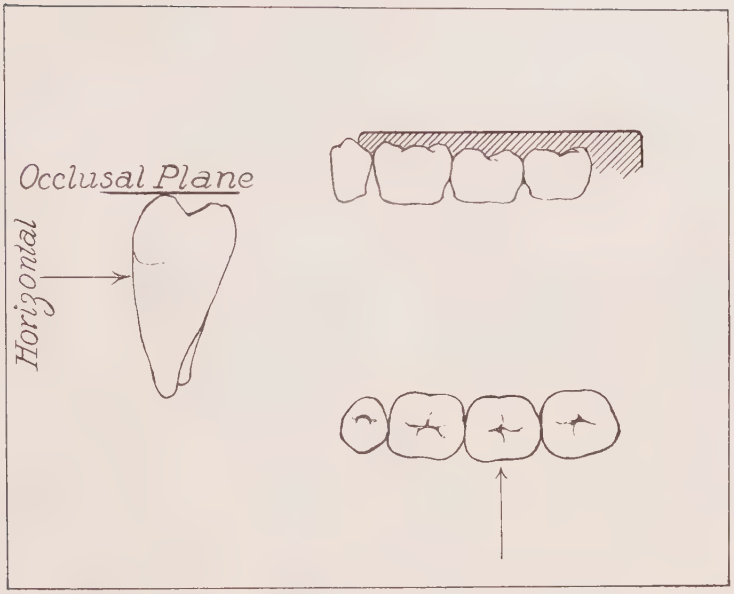


Fig. 88.—Diagrams of the position of the film packet, and the average angles of projection for examination of the mandibular second molar region.

Fig. 89.—Position of film packet and holder for the mandibular second molar region.

Explanatory Description.—The resistance and discomfort in placement of the film packet, and the superimposition of the external and internal oblique ridges when heavily formed, are the principal difficulties incident to examination of the mandibular second molar region.

The placement of the film packet to include the third molar region in some mouths requires considerable persistence and skillful manipulation, but can be endured

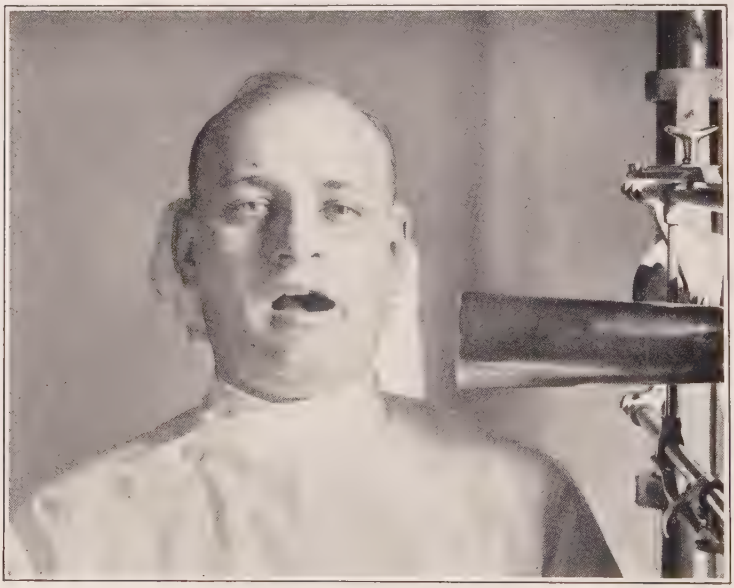
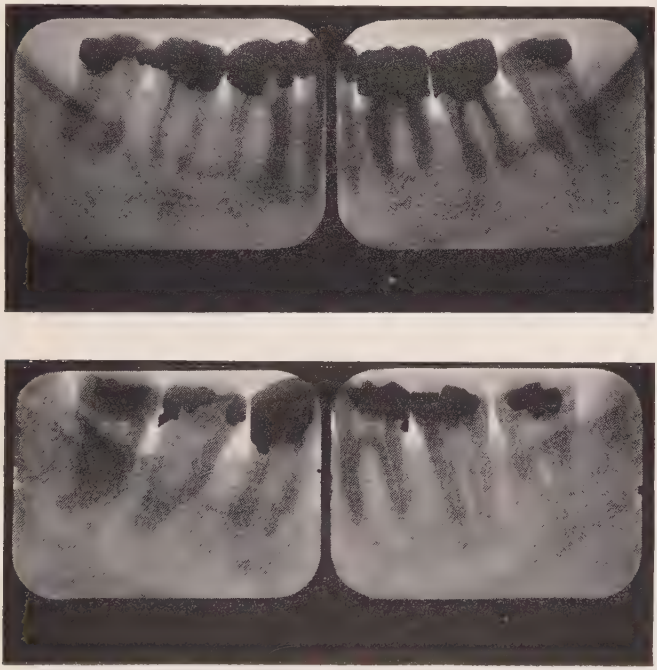


Fig. 90.—Position of patient and cone for the mandibular second molar region.

better than the patient is inclined to believe. The holder should be attached near the upper edge of the packet when the vertico-horizontal angle is horizontal or above so the image will be recorded to harmonize with that of the first molar region. The packet should be introduced between the tongue and molar teeth, and keeping the longer dimension approximately horizontal, forced downward and backward with an undulating movement to displace the soft tissues.

If excessive resistance is encountered, the lower distal corner of the packet is likely to be bent, and the first finger of the operator's adapting hand should be inserted between the tongue and the lower border of the packet to displace the tissues and straighten the packet. The packet must be tightly wedged in the holder, and the



Figs. 91 and 92.—Typical views of the mandibular second molar region.

patient cautioned not to swallow during the exposure to prevent movement of the packet. The largest of the Raper holders is especially useful in retaining the packet when the teeth in this region are absent.

The external or internal oblique ridge may obscure the second or third molar roots, and a deliberate modification of the angle of projection be indicated to better reveal conditions. Extreme inclination of the third molar may

place the apex in such close relation to the oblique ridge that superimposition cannot be avoided. The great variance in the lingual inclination of second and third molars requires a wider range in the vertico-horizontal angle for this than other mandibular regions, and fore-

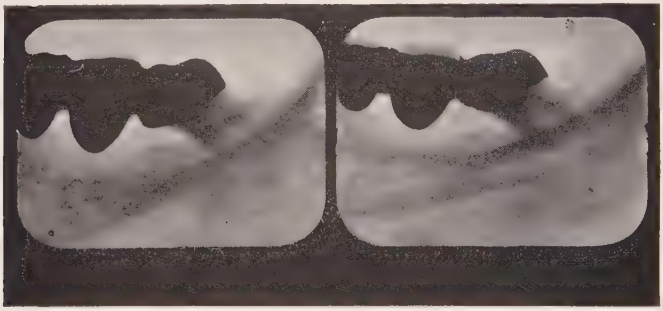


Fig. 93.—A case in which the external oblique ridge is superimposed at the apex of the third molar roots.

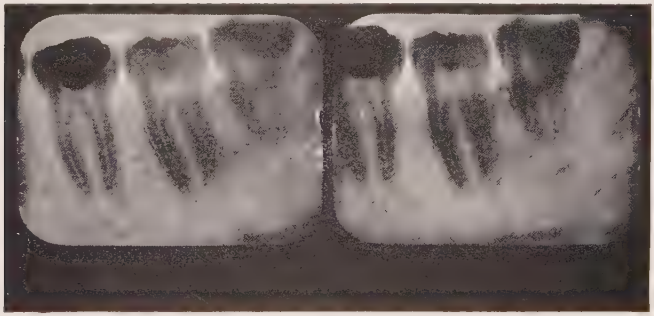


Fig. 94—A case in which extremely cancellous bone, and proximity of the mandibular canal render it difficult to determine periapical conditions of the second and third molar.

shortened images by the rays being directed from too low an angle is a common mistake.

The prevalent malposition of mandibular third molars often necessitates further examination at a greatly modified angle of projection, which should not be attempted in the routine examination of the region at the loss of information about the second molar. The periapical bone

in the second molar region, with the contiguous mandibular canal and a tendency to large medullary spaces, is the most confusing unobstructed area in which to determine conditions in an intraoral examination.

A slight increase in exposure is recommended for this over other mandibular regions because of the heavier

Fig. 95.—The twelve views of a systematic general radiodontic examination for a child before the eruption of the second molars.

alveolar process present, although it may result in overexposure of the area below the oblique ridges.

Intraoral Examinations for Children.—With patience and resourcefulness, intraoral examinations are possible for most children over four years old. The interest and cooperation of young patients should first be secured, and the current passed through the tube with the cone in position before placement of a film packet. When the prospect of unfavorable operating conditions is evident,

a short cone should be employed and the milliamperage increased to reduce the exposure time. If the examination is extensive enough to offer a choice, the easiest region, preferably the maxillary, incisor or cuspid, should be exposed first to acquaint the patient with the procedure. The aid of the parent or person accompanying the child should be enlisted in retaining the film packet and promoting immobility. With the temporary assistant at the patient's left side, the left first finger is used to retain the packets for the right regions while the right hand grasps the top of the child's head to steady it. For the left regions the assistant should stand at the patient's right side to retain the packets with the right first finger and hold the head with the left hand. Film holders retained either by the teeth or the assistant are indicated for the mandibular molar regions. Anesthesin-Calcidin troches (Abbott) or other local anesthetic should be used when there is discomfort or nausea from placement of the packets.

The vertico-horizontal angles of projection are 5 or more degrees higher for the maxillary regions and 5 or more degrees lower for the mandibular teeth than average angles for an adult. The higher angles of projection for maxillary regions apply until the age of sixteen or eighteen when with the exception of the third molar regions the full development of the alveolar process is reached. Twelve views with the second molar regions included with the first molars are the minimum requirement in a general radiodontic examination of children before the eruption of the second molars.

A spark gap of 3½ inches or 53 kilovolts is ample penetration for young patients. The imperfect muscle coordination of children demands short exposure even under favorable conditions. If the target-film distance is materially reduced and the milliamperage is increased to

the capacity of the tube, very short exposures are possible when required. In extreme emergencies, extra fast films permit further reduction of the exposure time.

When the film packets cannot be tolerated in the posterior regions, an extraoral examination may be substituted, but the necessity for maintaining immobility of the head and mandible is increased. Double coated films and intensifying screens are indispensable for extraoral examination of children. Bite-wing packets are especially useful in determining the condition of deciduous teeth as they cause less discomfort and offer a more favorable angle of projection than regular packets.

Interproximal Examinations.—An examination to disclose caries in the approximal surfaces of teeth and marginal destruction of the alveolar process has been developed by Dr. Howard R. Raper. With a special bite-wing packet which he designed for the purpose, the crowns and a portion of the roots of the maxillary and mandibular teeth in each region are examined together. By this method the number of exposures may be reduced to five, although seven views usually permit of better mesio-distal projection.

With the head posed so the occlusal plane is horizontal the average vertico-horizontal angle of projection is 10 degrees. The mesio-distal angle should be parallel with the approximal surfaces of the teeth in each region, with modifications for a marked malposition.

The film packets should be bent to conform to the obstructions presented, and adapted to each arch before placement. Hemostatic forceps or long beaked pliers are useful to hold the bite-wing in placing the packets for molar regions. The packets are retained by a firm pressure of the teeth upon the bite-wing, and for the incisor region the incisive edges of the mandibular and maxillary

teeth should be as directly opposed as conditions permit.

The spark gap should be from 3½ to 4 inches or 53 to 60 kilovolts, and the exposure 70 to 90 milliampere

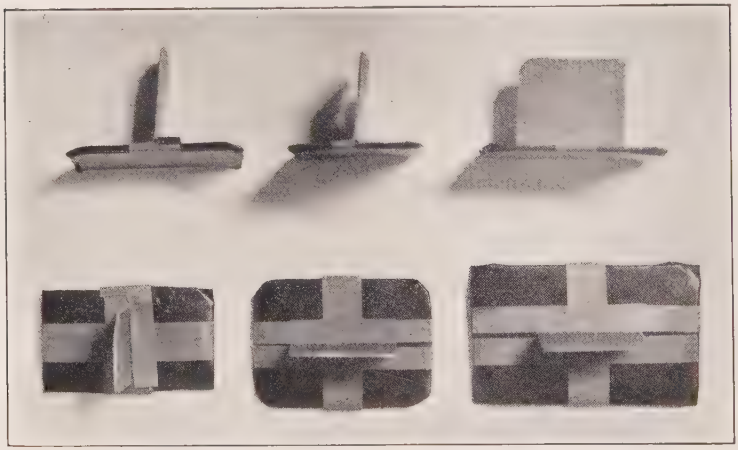


Fig. 96.—Bite-wing film packets for interproximal examinations. These packets were hand made in the early stage of their development.

seconds for the incisors and cuspids, and 90 to 120 milliampere seconds for the molars at an 18 to 20 inch target-film distance. A shorter target-film distance should not

Fig. 97.—An illustration of a five-view interproximal examination made with bite-wing film packets.

be used because the greater divergence of the rays increases the superimposition of the approximal surfaces of the teeth.

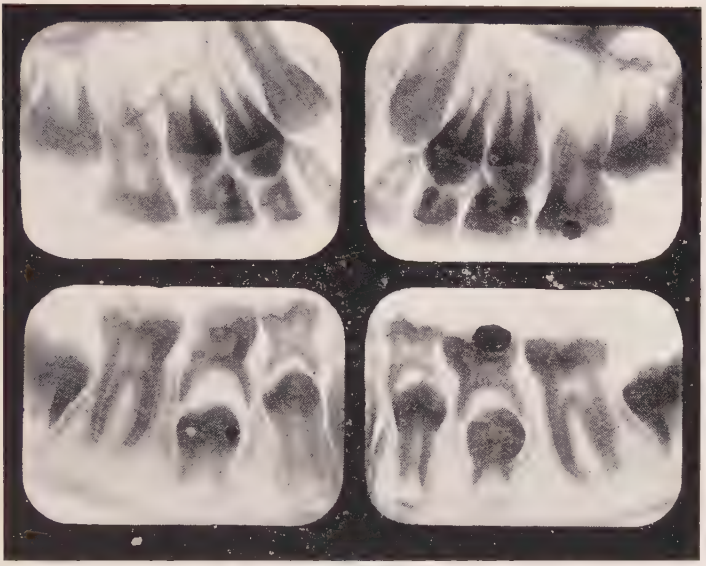


Fig. 98.—The customary lingual views of secondary dentition, which especially in the maxillary region because of the vertico-horizontal angle of projection do not show the relation of the permanent and deciduous teeth as accurately as an interproximal examination.

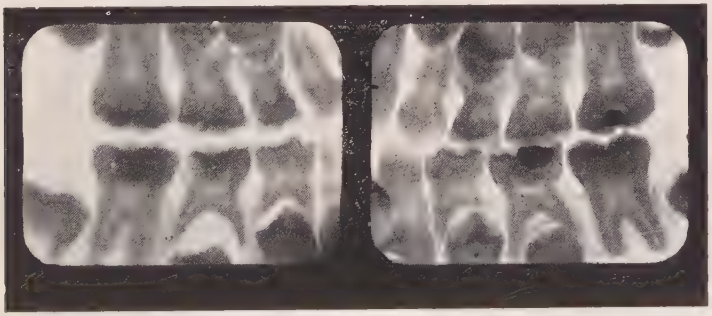


Fig. 99.—An interproximal examination presenting a more accurate view of the teeth illustrated in Fig. 98.

CHAPTER V

OCCLUSAL VIEWS

Maxillary Regions

Position of Head. Occlusal plane of maxillary teeth horizontal.

Anteroposterior Angle of Projection. Ten degrees posteriorly from vertical.

Modifications. Fifteen degrees or more for examinations of incisor regions. Vertical for examination of impacted third molars.

Lateral Angle of Projection. Vertical.

Placement of Film Packet. Number 2 extra fast films, or double coated films cut to suitable size placed with longer dimensions laterally.

Fig. 100.—The retention of the film packet, and position of patient and cone for an occlusal view of the maxillary region.

Retention of Film Packet. Firm pressure of opposing teeth on packet. Where a marked overbite or other irregularity of the occlusion bends the packet, a sheet of metal about 2½ inches square and 1 millimeter in thickness, with rounded edges and corners should be placed under the packet.

Cone. Centered over the frontal bone toward the center of the dental arch.

Spark Gap. 5 to 5½ inches, or 72 to 77 kilovolts.

Exposure. 180 to 220 milliampere seconds at an 18 inch target-film distance.

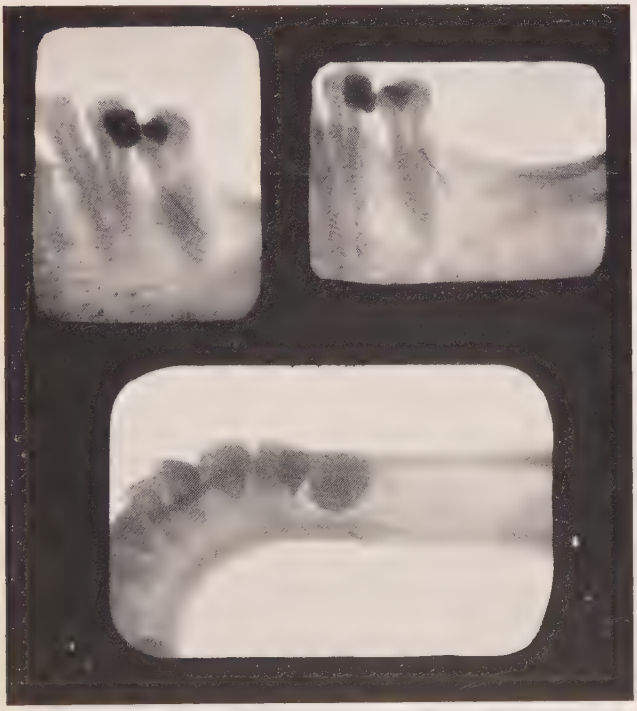


Fig. 101.—The two lingual views above illustrate localization by the "tube-shift" method in which the object farther from the tube apparently moves in the direction the tube is shifted. The occlusal view below gives not only the information of the "tube-shift" examination, but with a lingual view shows the exact location of the foreign object.

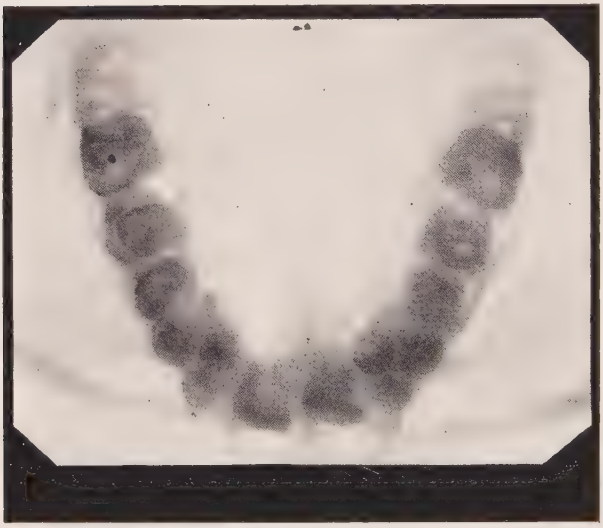


Fig. 102.—A maxillary occlusal view of deciduous and permanent teeth in which the relative location of twenty-four teeth is shown, the deciduous central incisors having been lost.

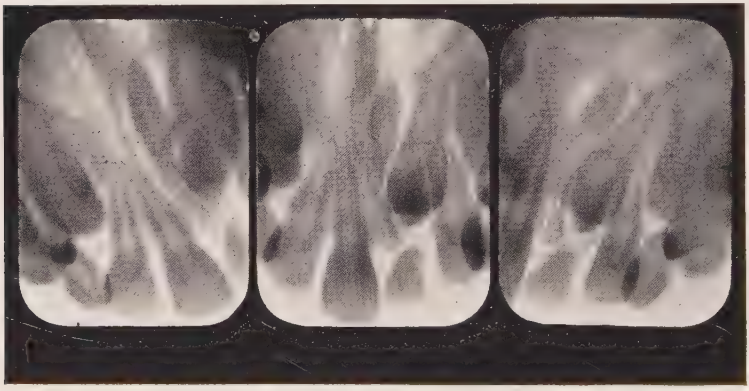


Fig. 103.—Lingual views of two supernumerary teeth and a retained central incisor, giving insufficient information regarding location and position.

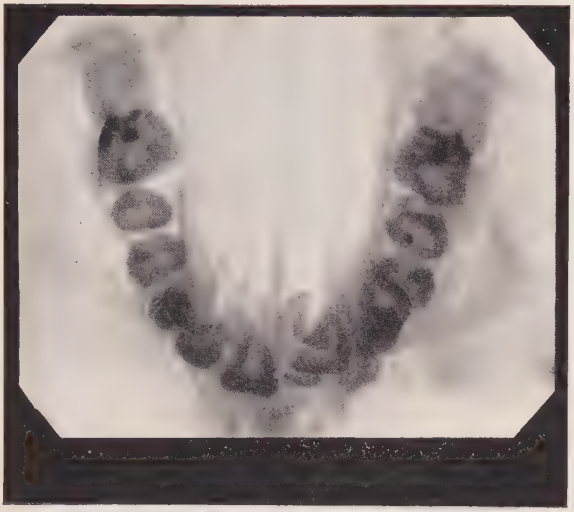


Fig. 104.—An occlusal view of the case shown in Fig. 103, supplying more definite information for the removal of the supernumeraries.

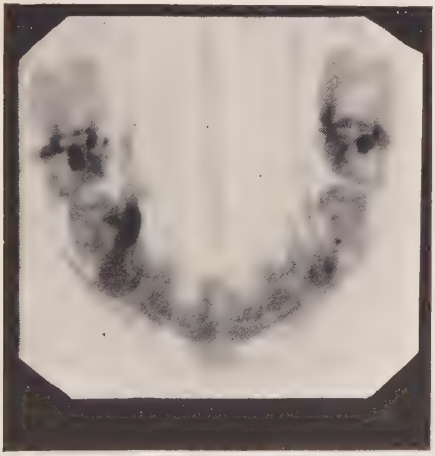


Fig. 105.—An occlusal view of the maxillary teeth of a four year old child. The secondary dentition from the first molars forward can be observed.

Explanatory Description.—Form, size, location, and position of objects are most accurately determined radiographically by viewing in two or more planes of the three

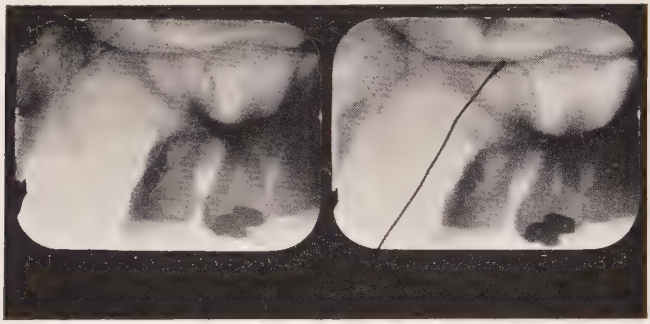


Fig. 106-*A*.—Lingual views of a cyst invading the maxillary sinus.

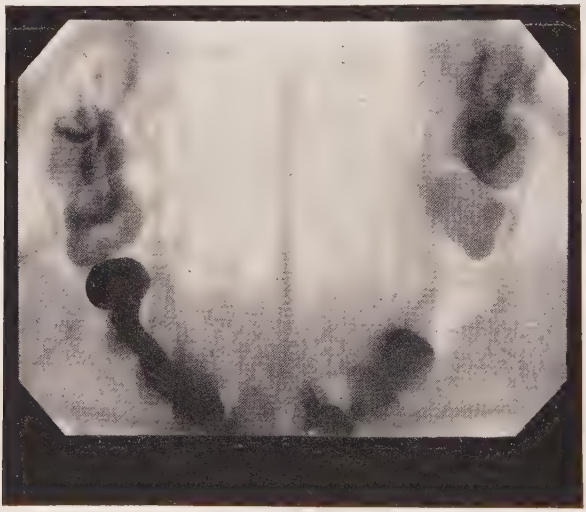


Fig. 106-*B*.—An occlusal view supplying additional information regarding the location and size of the cyst shown in Fig. 106-*A*.

dimensions. In intraoral radiography the limitations of projection in the customary lingual views, which does not exceed 25 degrees in the vertico-horizontal plane, often fail to supply the information desired for diagnostic and

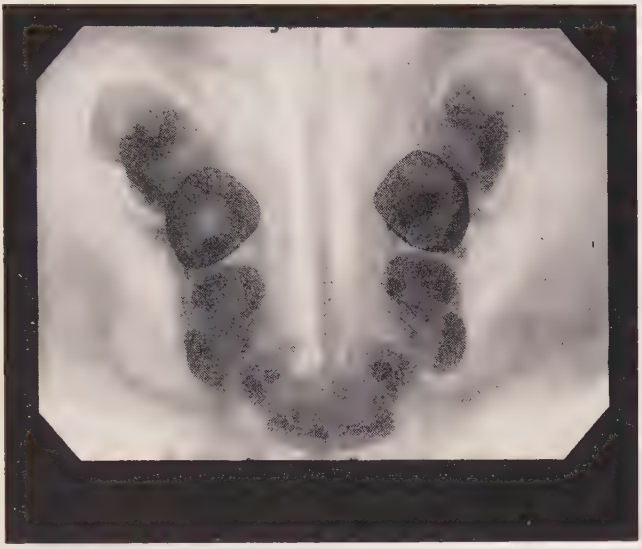


Fig. 107.—An occlusal view of extreme maxillary deformity.

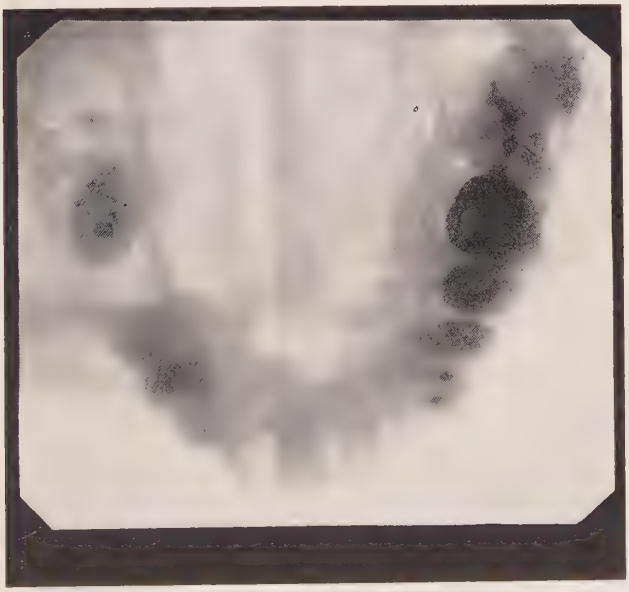


Fig. 108.—An occlusal view to localize the three root fragments of a maxillary second molar.

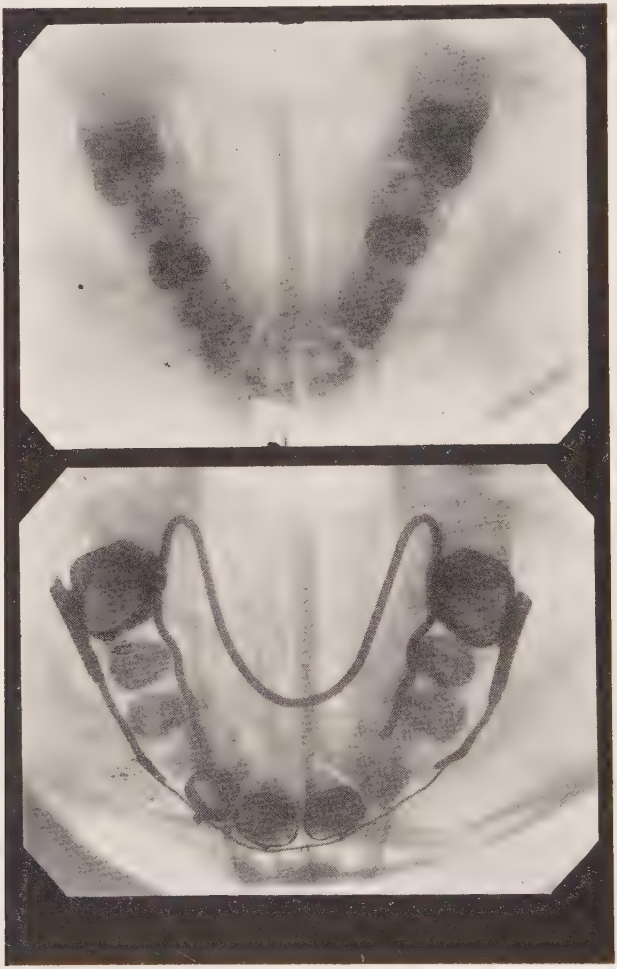


Fig. 109.—Occlusal views before and after orthodontic treatment for six months, showing the appliances in operation, and a striking record of the improvement in arch form.

operative purposes. Occlusal views in combination with lingual views extend the angle of projection to an arc ranging from 50 to 90 degrees, which approximately reveals the three dimensions of hidden objects.

This method is useful in obtaining information regarding unerupted teeth, congenital absence of teeth, pathologic conditions, anomalies, foreign bodies, arch forms, orthodontic appliances in operation, and the results of orthodontic treatment. Young patients are especially adaptable to these examinations since the digital retention of the packet, and the discomfort to the soft tissues are eliminated. Although the superimposed structures impair the definition and contrast in the negatives, this rarely thwarts the objective of the examination. The vertical portion of the frontal bone is the greatest obstruction encountered, and where it is parallel with the longitudinal axes of the incisors a modification of the anteroposterior angle is necessary to disclose this region.

The divergence of the rays from the target, closely coinciding with the general inclination of the maxillary teeth, permits a rather satisfactory view of the entire arch. When a special examination of a region is indicated, the angle of projection may be changed to parallel the longitudinal axes of the teeth. Where impacted third molars have forced the roots of the second molars forward, the angle of projection may be vertical or more anteriorly to accurately show the relation of these teeth.

The exposure and penetration recommended for this technic restrict the examinations to equipment of 72 kilovolts or greater capacity, and the number of exposures to two which may be safely made within a period of two to three weeks. The use of intensifying screens permits the examinations being made with less penetration and exposure, but the technic is more complicated and the accessories would have to be improvised.

Mandibular Regions

Position of Head. Reclined to the limit of flexibility with the body erect, in the attempt to place the occlusal plane vertical.

Anteroposterior Angle of Projection. Ten degrees posteriorly to the perpendicular of the occlusal plane for examination of the entire arch, or parallel with the longitudinal axes of the teeth for examination of a particular region.

Lateral Angle of Projection. Perpendicular to the occlusal plane for examination of the entire arch, or parallel with the longitudinal axes of the teeth for examination of a particular region.

Placement of Film Packet. Number 2 films placed with the longer dimension laterally for examination of the entire arch, or Number 1 and 1*a* films placed with the longer dimension mesiodistally for examination of a particular region.

Retention of Film Packet. Firm pressure of the opposing teeth on the packet.

Cone. Centered at the center of the arch for examination of the entire arch, or at the center of the region for examination of a particular region.

Spark Gap. 4½ to 5 inches, or 66 to 72 kilovolts.

Exposure. 110 to 150 milliampere seconds at a 20 inch target-film distance.

Fig. 110.—Position of patient and cone for an occlusal view of the mandibular incisor region.

Fig. 111.—Position of patient and cone for an occlusal view of the mandibular molar region.

Explanatory Description.—Occlusal views of the mandibular regions are less obscured by superimposed structures, but the operative technic is more exacting than that of the maxillary regions. The principal difficulties

Fig. 112.—Occlusal view of mandibular arch in young patient.

encountered are the uncomfortable pose, the proximity of the tube to the patient, and the lingual inclination of the posterior teeth.

The pose presents little difficulty with young or supple patients, but with elderly or obese patients, especially women with liberal bust development, the physical limita-

tions materially impair the results. Some types of tube stands and brackets do not permit the tube's being placed in the proper position for these examinations and with any equipment care must be exercised in keeping the high voltage connections a safe distance from the patient. A rubber mat placed over the body and arms of the patient is an additional precaution.

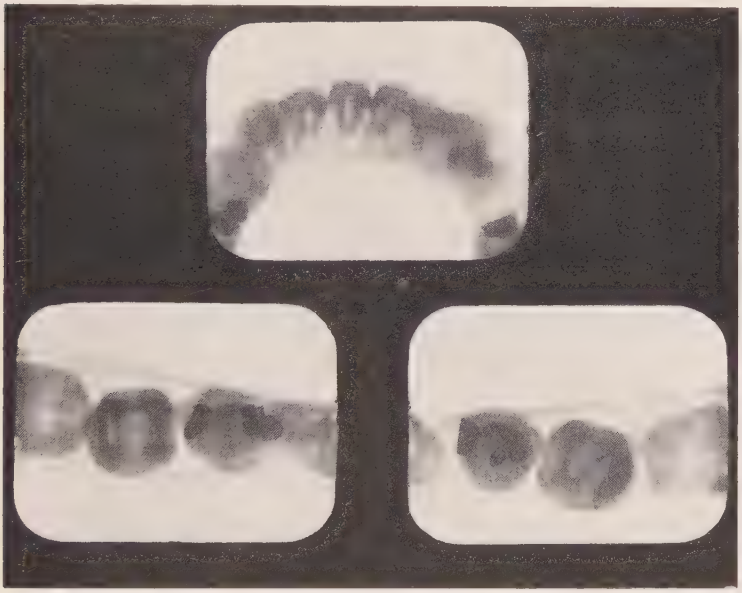


Fig. 113.—The three views which are required for a true occlusal examination of the mandibular arch because of the marked deviation in the longitudinal axes of the teeth.

The convergence of the mandibular teeth in different planes from the divergence of the rays preclude a true occlusal view of the entire arch, but a rather satisfactory view of the dentition to the age of twelve is possible. After the eruption of the permanent teeth, at least three views are required to approximately parallel the longitudinal axes of the teeth: one for the incisors and cuspids, and one for the bicuspids and molars on each side

Films of the 1*a* size are suitable for the three view method, but for examination of a particular region the metal backed Number 1 films produce the best results.

To accurately parallel the longitudinal axes, close observation of the position of the teeth and the direction of the cone is required after the patient is posed. In the first attempts, the operator usually underestimates the inclination of the teeth, and fails to obtain a true occlusal view. For an illustration of the marked lingual inclination, in the second molar region the average lateral direc-

Fig. 114.—Localization of an odontoma and displaced tooth in mandibular incisor region.

tion of the rays for an occlusal view is through the teeth and the inner corner of the opposite eye.

It is especially necessary to parallel the longitudinal axes of the teeth for localization in the incisor region, as a slight deviation will be misleading in relations around the apices of the teeth. When the prevalent labial inclination of the incisors is so extreme that the rays cannot be correctly directed incisally, the method may be reversed for a submandibular view by placing the film under the chin and directing the rays apically. For this method the head is slightly reclined; the film resting on a

flat object is pressed against the lower border of the mandible with the surface as nearly perpendicular to the teeth as possible; the mouth is opened to the limit and the rays are directed downward parallel with the longitudinal axes of the teeth.

In obtaining occlusal views for the localization of unerupted third molars, the film packet should not be forced distally until bent by the ramus. In most cases only the

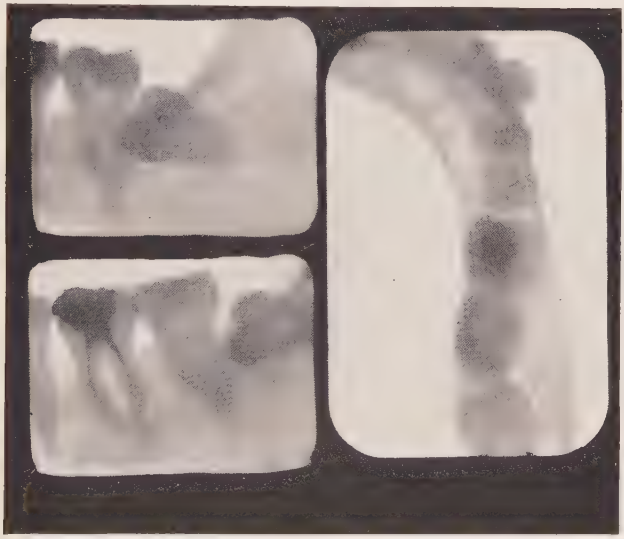


Fig. 115.—The upper lingual view had been misinterpreted as resorption of the second molar, and the tooth condemned. The occlusal view shows the direction for the rays to disclose the relation of the second and third molar. The lower lingual view in this direction shows the second molar intact, and changed the indications for treatment to the removal of the third molar.

crown of the third molar can be included, and an attempt to extend the field beyond this point results in objectionable distortion of the image. The posterior buccal corner of the packet should be sharply bent upward, and the packet carried distally until it meets obstruction by the ramus.

In placing the packet for occlusal views of mandibular regions, allowance should be made for the angle of pro

jection so that the image will be symmetrically registered on the film. This requires the greater portion of the packet to be placed toward the lingual for the posterior regions, and toward the labial for anterior regions. The location of the packet should be determined before the teeth are closed, as the heavy impact produces indenta-

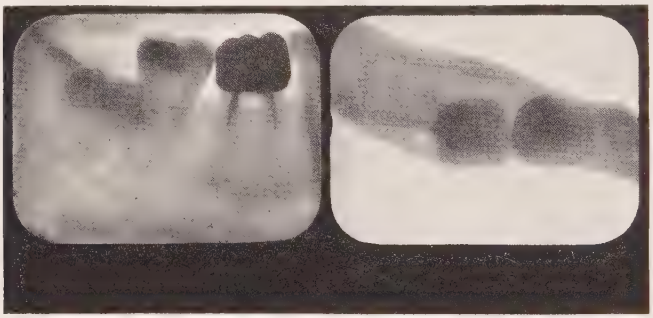


Fig. 116.—A lingual view showing an apparent lingual displacement of an impacted third molar. The occlusal view reveals it as a buccal displacement.

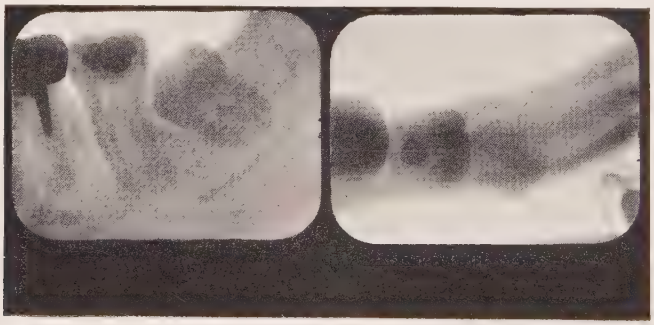


Fig. 117.—Distortion of an occlusal view from bending of the film in attempting to cover a too extensive field.

tions which are visible in the developed film. The exact placement of the packet can best be controlled by firmly grasping the external edge, resting it on the mandibular teeth, and following the movement of the mandible until the packet is retained by the opposing teeth. In directing the patient to bite on the packet, the instruction

should be to "slowly close" instead of "close slowly" to avoid the impulsive completion of the act before the verb can be modified.

The exposure recommended is for "regular" films, as "extra fast" films are indicated only for occlusal views of maxillary regions or other special requirements.

CHAPTER VI

EXTRAORAL EXAMINATIONS

Position of Head. Reclined to the limit of flexibility. Sagittal or median plane vertical. Cheek in contact with cassette or film container. For the condyle, face turned very slightly toward the cassette. For molar regions, tip of nose about one inch from the cassette. For the cuspid and bicuspid regions, nose in contact with cassette. For incisor regions, head inclined backward and laterally to the limit of flexibility, with the nose and chin pressed tightly against the cassette.

Anteroposterior Angle of Projection. Perpendicular to the cassette.

Vertico-horizontal Angle of Projection. Twenty-five degrees below horizontal.

Fig. 118.—Position of cone, head, and cassette for an extraoral view of the molar regions.

Placement of Cassette. With the arm of the operating chair removed, the patient is directed to turn until the region to be examined is toward the headrest. The cassette is rested against the headrest and inclined ten degrees toward the neck from vertical.

Retention of Cassette. Supported by patient's shoulder and hand for lateral regions, and both hands for incisor regions. Immobility promoted by a tight bandage around patient's head, cassette and headrest.

Cone. Centered at the center of the region to be examined.

Spark Gap. 4½ to 5 inches, or 66 to 72 kilovolts.

Exposure. Cuspid and posterior regions 40 to 60 milliampere seconds at a 40 inch target-film distance with double coated films and intensifying screens, 200 to 250 milliampere seconds without screens. Incisor regions 100 to 150 milliampere seconds with screens, and impracticable at this distance without screens.

Fig. 119.—Position of cone, head, and cassette for an extraoral view of the cuspid and bicuspid regions.

Explanatory Description.—Extraoral examinations are indicated for hypersensitive patients who cannot retain the intraoral packets in posterior regions, for children to eliminate the discomfort and necessity of cooperation in intraoral examinations, where trismus or acute inflammation prevents intraoral examination, and where it is de-

Fig. 120.—Position of cone, head, and cassette for an extraoral view of the incisor regions.

sired to extend the examination to areas not covered by intraoral examinations.

The limitation of extraoral examinations is the impaired definition in the negatives because of the superimposed structures, and the distance of the parts from the film. This restricts the information obtainable to the grosser structures and lesions. The excessive distortion of the images and the avoidable superimposition of struc-

tures commonly evident in extraoral views can be obviated by application of the technic here described. By having the anteroposterior angle of projection perpendicular to the film and turning the head for the different regions the distortion is minimized, while the extreme bending of the neck with the teeth in occlusion removes the cervical vertebrae from superimposition on the region

Fig. 121.—Illustrating the use of a bandage to promote immobility during extraoral examinations. The position of the head in this illustration is for a view of the condyle.

being examined. The greater target-film distance than for intraoral examinations is recommended to minimize the distortion of the images, and the effect of unavoidable movement of the patient.

Immobility is essential to the success of extraoral examinations and every available means to secure it should be utilized. Tables or stands with head clamps are most

efficient for fixation, but the uncomfortable pose required detracts from the advantages in their use. The tight bandage illustrated and described serves the purpose and dispenses with the additional equipment. Just a few seconds before the exposure is begun, the patient should be requested to hold the breath and cautioned not to move.

Fig. 122.—Illustrating the use of a stand with head clamps for extraoral examinations.

Although extraoral examinations may be made with films or plates in containers without intensifying screens, the excellence of modern screens makes it desirable to use the double screen method to shorten the exposure. The 8 x 10 inch size is the most appropriate for cassettes and films used in extraoral and sinus examinations. In calculating the exposure and judging the development of

Fig. 123.—An extraoral view of the molar regions. Note how the regions under examination are freed of the avoidable superimposition without distortion of the images.

Fig. 124.—An extraoral view of the cuspid and bicuspid regions.

Fig. 125.—An extraoral view of the incisor regions. This view is not generally used or appreciated, but is useful in localization and in suspected fracture of the mandible.

the image the operator should consider that the skull and superimposed portions of the negative must be light or thin to render the proper density to the region under examination, and local reduction of the negative will improve the diagnostic quality.

CHAPTER VII

STEREOSCOPIC EXAMINATIONS

Position of Head. Same as for plane examinations of the region. Immobility promoted by clamps or a tight bandage around head and headrest.

Vertico-horizontal Angle of Projection. Same as for plane examinations of the region.

Mesio-distal Angles of Projection. The angles resulting from shifting the target $1\frac{9}{32}$ inches to the left and right from the usual mesio-distal angle of projection.

Placement and Retention of Film Packets or Cassettes. Same as for other examinations of the region.

Cone. Centered as for plane examinations of the region, after the tube is shifted for each exposure.

Spark Gap. Same as for other examinations of the region.

Exposure. Same as for other examinations of the region with care to give approximately the same exposure to each view.

Fig. 126.—Application of bandage to promote immobility in stereoscopic intraoral examinations.

Explanatory Description.—Stereoscopic extraoral examinations often supply diagnostic information regarding extensive pathologic processes, foreign bodies, and traumatic injuries by differentiating superimposed structures and outlining cavities. Stereoscopic intraoral examinations are an interesting diversion, but are of questionable utility in radiodontic practice because of the greater accuracy of occlusal views in localization; while the boasted claims of determining the lingual or facial displacement of an unerupted tooth can be accomplished by the simple variance of plane lingual views.

Stereoscopic intraoral examinations were first made by Dr. C. Edmund Kells in 1902, and no one has materially improved the technic developed by him, although uninformed novices sometimes feature it as a new method. References to the subject in textbooks and monographs usually exaggerate the difficulty of the method, and suggest wonderful possibilities when it is mastered or a simple technic is devised; while in fact a stereoscopic examination is the same as any other two exposures of a region, except that the tube target is shifted 65 mm. and the patient must not move between exposures. In contrast to the confusing instructions for viewing, just hold the films in the same plane before a hand stereoscope, move them until the images fuse, and a stereoscopic view is obtained of the lingual or facial aspect depending upon the right or left relation of the films. These statements are not intended to imply that accurate stereoscopic examinations can be made without the careful and precise technic which is requisite for all oral examinations, but to dispel the impression of mystery and extreme difficulty commonly associated with the method.

Stereoscopic radiography is based upon the principle of binocular vision or the fusion of the images seen with each eye, by which size, form, and distance are judged.

The average distance of pupillary separation is 65 mm., the extremes ranging from 60 to 70 mm. Hence, in accurate stereoscopic radiography the tube target is shifted 65 mm. or $2\frac{9}{16}$ inches between the exposures and the radiographs are viewed at the target-film distance. Some tube stands are so designed that an excessive target shift results from centering a small cone after the lateral move-

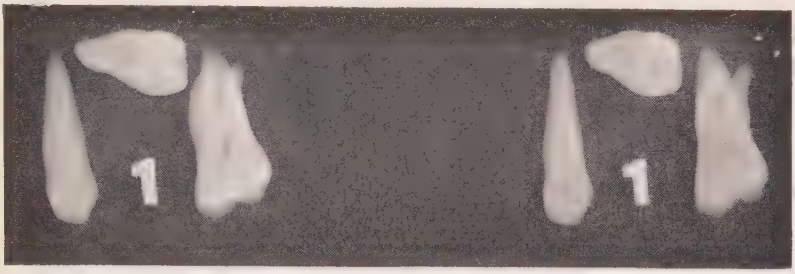


Fig. 127.—A stereoscopic view of a malposed tooth made under favorable inanimate conditions.

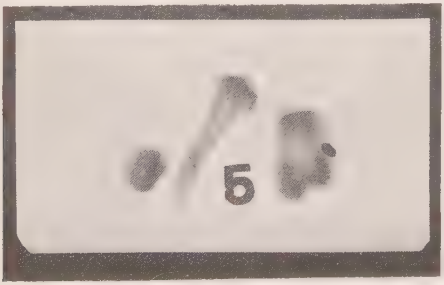


Fig. 128.—An occlusal view of the teeth in Fig. 127, illustrating the more definite localization.

ments of the carriage; and this should be corrected by a compensating reduction in the lateral movement. Stereoscopic examinations for the purpose of localization should exactly adhere to the geometric laws of binocular vision, but for diagnostic purposes an increase in the target shift over the pupillary separation amounting to 5 per cent of the target-film distance gives an exaggerated separation of planes which is desirable.

The cooperation of the patient and the operative expediency is more exacting than the specific requirements of the technic. The patient should be emphatically told that two exposures are to be made and immobility is required until the second exposure is completed. The tube stand and chair should be locked in position, and the

Fig. 129.—A stereoscopic view of a radicular cyst which discloses the outlines of the cavity, but gives no clew to the extensive buccal involvement shown in Fig. 130.

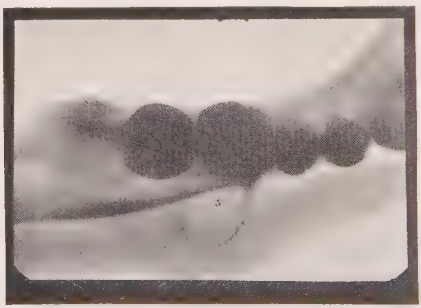


Fig. 130.—An occlusal view of the cyst shown in Fig. 129 which accurately shows the extent of involvement toward the buccal.

patient's head securely retained. In calculating the mesio-distal angles of projection the tube carriage should be placed midway between the lateral shifts with the cone directed to give the desired view as established by preliminary exposures, and then trial shifts made with recentering of the cone to observe the effect of the changes. The precaution often prevents unexpected com-

plications in the location of the tube stand or the pose of the patient after the first exposure.

For intraoral examinations the two film packets should be readily accessible, and provision made for the quick disposal of the first to reduce the time between the ex-

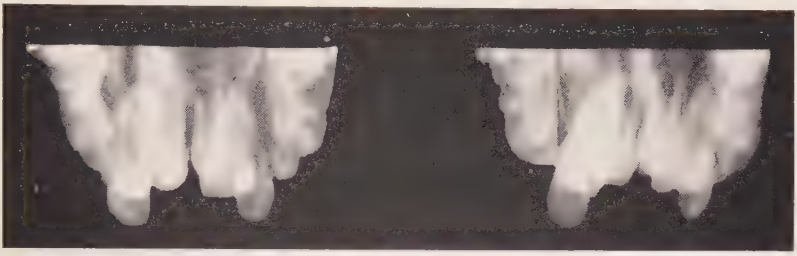


Fig. 131.—A stereoscopic view of unerupted teeth and supernumeraries.

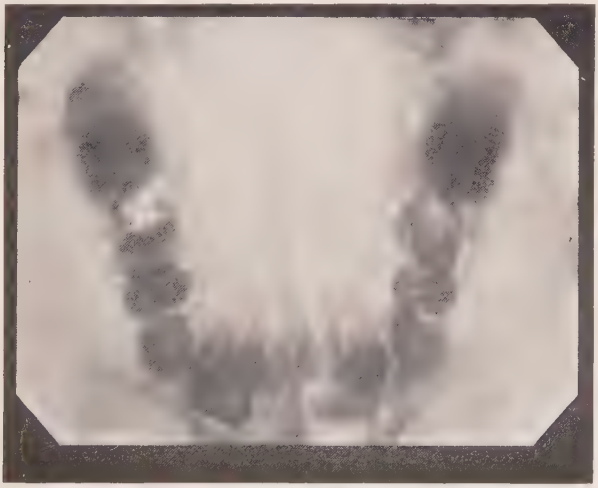


Fig. 132.—An occlusal view of the teeth shown in Fig. 131, with definite localization.

posures. For convenience the packets should be marked before or after exposure and when removed to the dark room perforated with a pin to distinguish the left and right views, and stereoscopic films from others of the examination.

The film packets may be retained in the mouth by holders, digital retention, or when placed in the occlusal plane by occlusal pressure of the teeth. Most stereoscopic examinations of the maxillary regions have been made with the packets in the occlusal plane, but excepting the localization of unerupted teeth a better diagnostic view is obtained with the packets in contact with the soft tissues. Elaborate means have been described and employed to place the packets in exactly the same location but, as Dr. Kells long ago observed, it is only necessary to place them in the same plane. For uniformity the packets should be placed in approximately the same location, but this has no bearing on the result so long as the area under examination is included.

The films may be viewed by holding them on a piece of glass in a hand stereoscope, or they may be mounted on glass with adhesive paper strips. Although the films may be viewed from either side or either lateral relation, the perspective is more vivid when viewed from the nonemulsion side with the left exposure mounted to the viewer's left because of the exaggerated aerial perspective in radiographic records from underfiring or scattered radiation. The left exposure is that made with the tube shifted toward the operator's left when facing the patient. To easily fuse the images in the stereoscope, one film should be placed in the approximate location and the other moved to conform while viewing them. Where there are no metallic restorations in the region, a lead or wire marker aids in fusing the images. Theoretically the films should be viewed at the target-film distance, but considerable latitude is permissible through ocular accommodation and preconception of the structures.

For stereoscopic extraoral examinations a changing tunnel is required to change the films without disturbing the pose of the patient. Dr. Frank Van Woert designed

a film-shifting tunnel which makes it possible to produce both views on a 5 x 7 film and view them in a hand stereoscope. A wheatstone or reflecting stereoscope is generally used in viewing extraoral examinations, but the films may be trimmed to a size which can be mounted for a hand stereoscope. There is no need to mark the left and right exposures or the front or back of double coated films, for when the images fuse the tube or film aspect is obvious, but the left and right sides of the patient should be designated by markers.

CHAPTER VIII

SINUS EXAMINATIONS

Lateral View

Placement of Cassette. With the arm of the operating chair removed, the patient is directed to turn until the side of the head is toward the headrest. The cassette in a vertical position is rested against the headrest.

Retention of Cassette. Supported by the patient's shoulder and nearer hand. Immobility promoted by a tight bandage around patient's head, cassette, and headrest.

Position of Head. Sagittal plane vertical, and parallel with cassette.

Anteroposterior Angle of Projection. Perpendicular to cassette.

Vertico-horizontal Angle of Projection. Perpendicular to cassette, or horizontal.

Cone. Centered at external margin of the orbit.

Spark Gap. 5 inches, or 72 kilovolts.

Exposure. 80 to 120 milliampere seconds at a 40 inch target-film distance, with double coated films and intensifying screens.

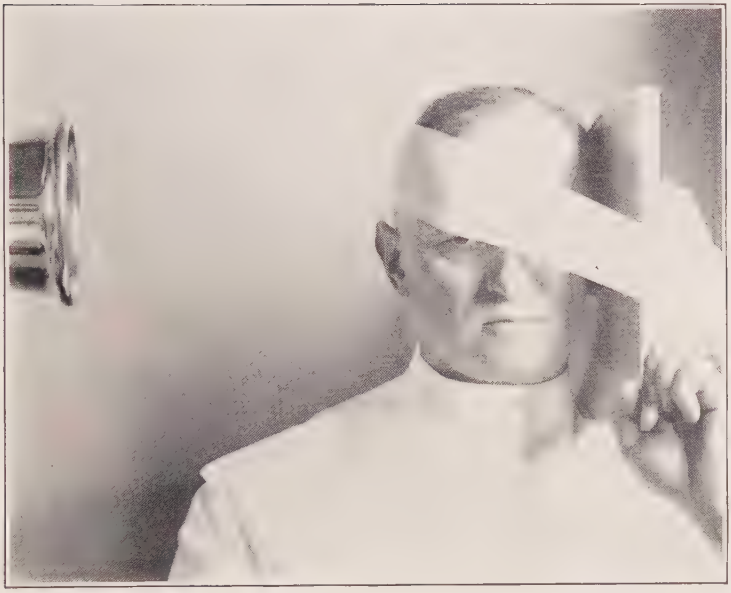


Fig. 133.—Position of patient, cassette, and cone for a lateral examination of the paranasal sinuses.

Fig. 134.—A lateral view of the paranasal sinuses.

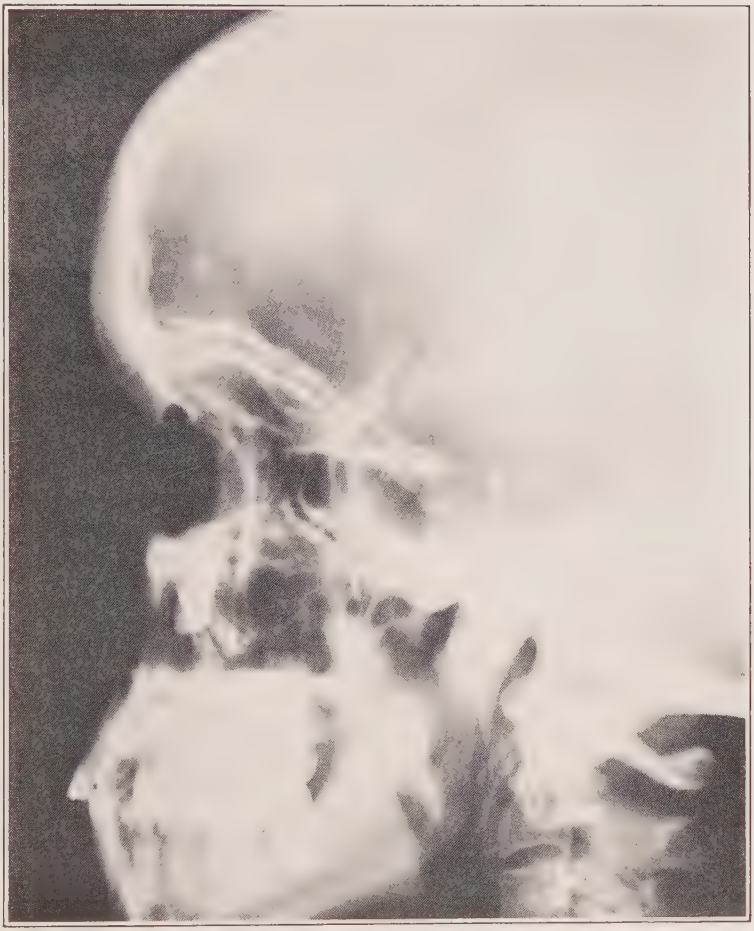


Fig. 135.—A lateral view demonstrating the absence of frontal sinuses in the vertical portion of the bone.

Anteroposterior View of Maxillary Sinuses

Placement of Cassette. Horizontal, or inclined ten degrees toward patient when there is difficulty in posing.

Retention of Cassette. Supported by a stand or table.

Position of Head. Sagittal plane vertical, forehead on cassette, and nose pressed tightly against cassette. Immobility promoted by head clamps, or a tight bandage around patient's head and cassette.

Anteroposterior Angle of Projection. Perpendicular to cassette. *Modifications.* Five degrees or more above or below perpendicular as the average position of the head is changed by the facial profile, and the size and compressibility of the nose. Five or ten degrees below perpendicular for children.

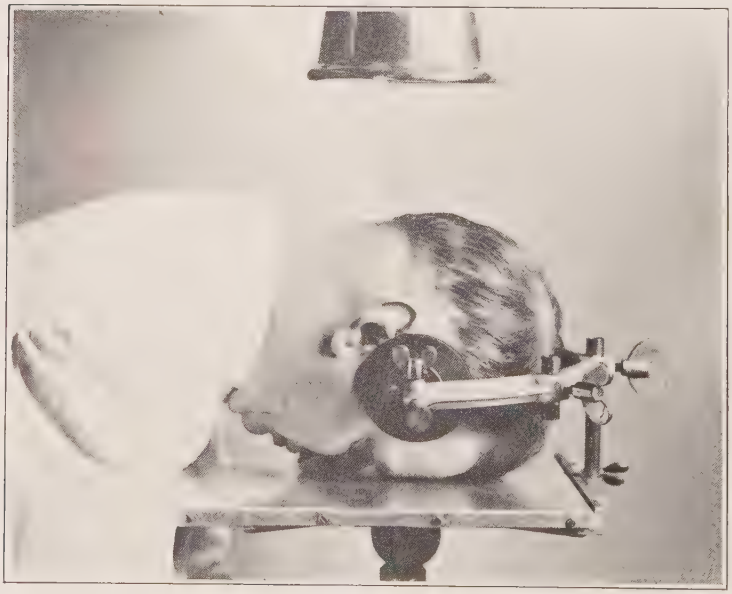


Fig. 136.—Position of patient, cassette, and cone for an anteroposterior examination of the maxillary sinuses.

Lateral Angle of Projection. Perpendicular to cassette.

Cone. Centered just below the occipital protuberance.

Spark Gap. 4½ to 5 inches, or 66 to 72 kilovolts.

Exposure. 100 to 140 milliampere seconds at a 30 inch target-film distance, with double coated films and intensifying screens.

Fig. 137.—An anteroposterior view of the maxillary sinuses.

Anteroposterior View of Frontal Sinuses

Placement of Cassette. Horizontal, or inclined ten degrees toward patient when there is difficulty in posing.

Retention of Cassette. Supported by a stand or table.

Position of Head. Sagittal plane vertical, forehead on cassette, and nose pressed tightly against cassette. Immobility promoted by head clamps, or a tight bandage around patient's head and cassette.

Anteroposterior Angle of Projection. Fifteen degrees above perpendicular to the cassette.

Modifications. Ten to twenty degrees above perpendicular as the average position of the head is changed by the facial profile, and the size and compressibility of the nose.

Fig. 138.—Position of patient, cassette, and cone for an anteroposterior examination of the frontal sinuses.

Lateral Angle of Projection. Perpendicular to the cassette.

Cone. Centered at juncture of the occipital and parietal bones.

Spark Gap. 5 to 5½ inches, or 72 to 77 kilovolts.

Exposure. 120 to 160 milliampere seconds at a 30 inch target-film distance, with double coated films and intensifying screens.

Fig. 139.—An anteroposterior view of the frontal sinuses.

Special Examination of Sphenoidal Sinuses

Position of Head. Occlusal plane of maxillary teeth horizontal. Head supported by headrest.

Anteroposterior Angle of Projection. Twelve degrees posterior to vertical.

Modification. Ten to twenty degrees posterior to vertical depending upon the tolerance of the patient for insertion of the cassette.

Lateral Angle of Projection. Vertical.

Placement of Cassette. With the tube and head in position, and the mouth open, gently insert the cassette as far posteriorly in the pharynx as it can be endured.

Retention of Cassette. Firm pressure of the teeth on cassette, immediately after placement.

Cone. Centered at the juncture of the frontal and parietal bones.

Spark Gap. 4½ inches.

Exposure. 40 to 60 milliampere seconds at a 20 inch target-film distance, with double coated films and intensifying screens.

Fig. 140.—Position of patient, cassette, and cone for a special vertical examination of the sphenoid sinuses.

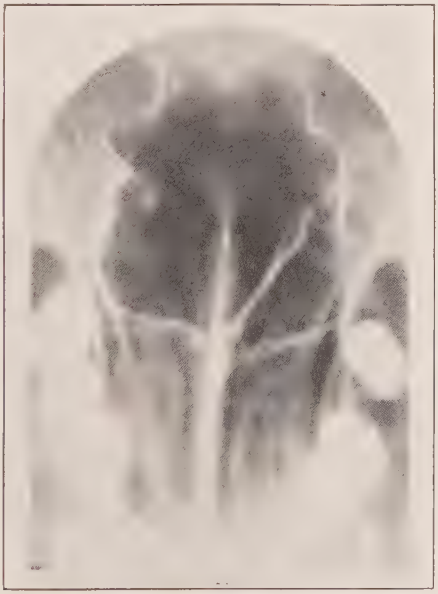


Fig. 141.—A vertical view of the sphenoid sinuses.

Explanatory Description.—The proximity of the accessory nasal sinuses to the mouth, the relation of sinus and oral diagnosis, and the lack of systematic technic in sinus radiography warrant a chapter on sinus examinations in this book. The technic here described is based on the fundamental principle of placing the region to be examined in the closest possible relation to the film, and presents no restriction on the angle of projection. The common error of limiting a sinus examination to one view, and attempting to diagnose conditions from this inadequate evidence is a reflection on the efficiency of radiographers, and among rhinologists has brought radiography into disrepute as a diagnostic aid.

The three routine views described should be the minimum requirement in a radiographic examination of the paranasal sinuses. The lateral view shows the anteroposterior extent of the maxillary and sphenoid sinuses, and is indispensable for a thorough examination of the frontal sinuses by revealing their depth and the thickness of their walls. Without the lateral view, average bilateral radiolucence in the anteroposterior view would be interpreted as normal while it may be significant of disease in deep frontal sinuses with thin walls, and radiopacity of varying degree may be entirely due to anatomic factors. To obtain reliable information from this view, the technic must be accurate in producing correct perspective. The endeavor should be to sharply project the sagittal section of the accessory sinus region without distortion or avoidable superimposition. Therefore the rather long target-film distance recommended is one of the essential factors in this examination. The coincidence of the orbits is an accurate check on the perspective of this view rather than the mandible or other more obvious landmarks which are not in the path of the central rays.

One anteroposterior view is required for the maxillary

sinuses, and another for the frontal sinuses because both regions cannot be shown to the best advantage in one view. The maxillary sinuses are most clearly revealed by projecting the occipital bone and the petrous portion of the temporal bone just above these sinuses. In this view the frontal sinuses are foreshortened and insufficiently exposed, because more penetration and exposure are required to penetrate the cranial bones than the

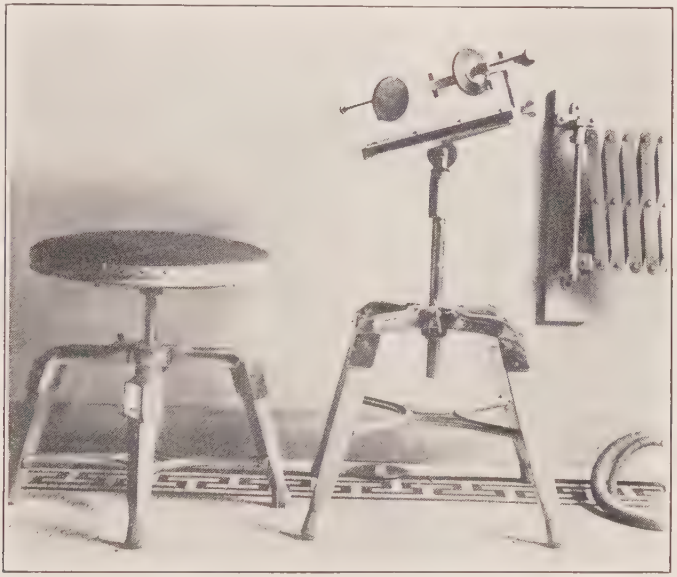


Fig. 142.—An adjustable stand and stool designed by the author for anteroposterior sinus examinations, which obviates the use of a table.

cervical and facial structures. For dependable information the anteroposterior view of the maxillary sinuses must parallel the sagittal plane, or there will be a difference in the apparent radiolucence of normal sinuses because the adjacent structures are not uniformly superimposed. The sagittal plane may be placed vertically by leveling the posterior attachment of the external ears. This is easily done by standing behind the patient after

the head is on the cassette, bending the pinnae forward and viewing the posterior surfaces of the conchae as they are leveled. The accuracy of projection in the sagittal plane can be verified in the negative by the sharp cross-section image of the vomer, and the equality of the triangular areas bounded by the internal surface of the mandible, and the alveolar and malar processes of the maxillae with allowance for a unilateral edentulous molar region.

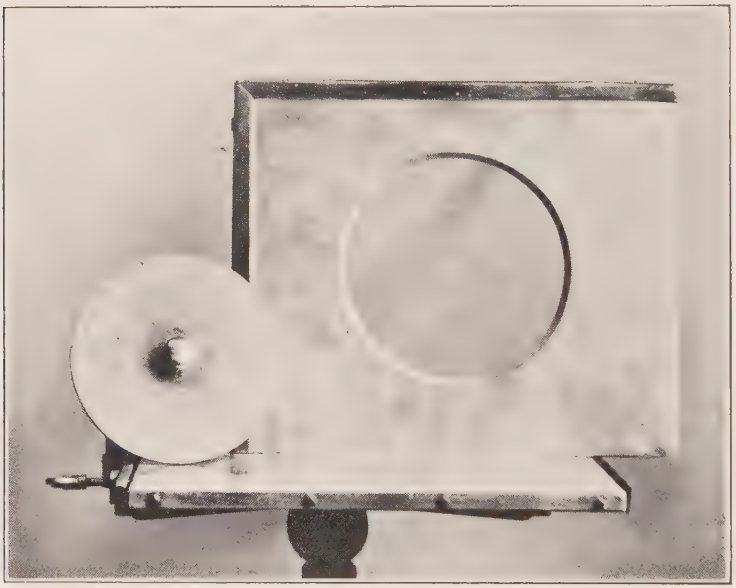


Fig. 143.—A lead shield to reduce the effect of secondary radiation in sinus examinations, and a corresponding lead disc to cover the latent image while the remainder of the film is exposed to produce an opaque margin which is advantageous in viewing.

The latitude in the vertico-horizontal angle of projection is occasioned by the difference in facial profiles and the size and compressibility of noses. Close observation of the relation of the profile to the cassette and palpation of the occipital protuberance will enable the operator to estimate the deviation indicated from the average angle of projection. With a definite pose and angle of projec-

tion an error in calculation can be corrected in subsequent exposures by a deliberate change in the angle of projection. Any technic for radiographic examination of the sinuses in which the face is rested on the cassette should be modified for variations in profiles. Ignoring facial contour is the absurdity and factor of error, in the alleged classic methods of the past which emphasized an arbitrary angle of projection for examination of the accessory sinuses. That the "rule of thumb" which prevails in

Fig. 144.—The Pfahler cassette and envelope to be inserted in the mouth for a vertical view of the sphenoid sinuses.

the omniscient practice of general radiography results in ignominious failure when applied above the clavicle has been amply demonstrated.

The most valuable anteroposterior view of the frontal sinuses is perpendicular to their superoinferior diameter. This projection also reveals the ethmoid cells, the sphenoid sinuses and a supplemental view of the maxillary sinuses. The same landmarks apply in placing the sagittal plane vertical and in determining the accuracy of the projection as in the anteroposterior view of the

maxillary sinuses. In anteroposterior stereoscopic examinations of the accessory sinuses, the tube should be shifted in the sagittal plane instead of laterally, so the sagittal view will be maintained in each exposure. The stereoscopic examination should be preceded by one or more exposures to determine the most advantageous mean angle of projection from which to shift the tube.

The special examination for a vertical view of the sphenoid sinuses was introduced by Dr. George E. Pfahler, and is a marked improvement over the former methods of placing the cassette under the mandible or at the top of the head. The intraoral placement brings the cassette closer to the sphenoid region to produce sharper definition in the image than by other methods, and the technic is quite simple. Aside from the diagnostic value, this examination is particularly useful for operative purposes in showing the access, size and form of the sphenoids, and the location of the septum.

Ample exposure followed by local reduction as described in the next chapter gives additional information in radiographs of the paranasal sinuses, because of the greater radiability of the facial than the cranial bones.

CHAPTER IX

PHOTOGRAPHIC PROCESSES

The preceding chapters have described methods of registering the latent image on the film after which chemical processes are required to disclose it and produce a visible record. These distinct phases of radiography are equally important, for as either the projection of the image or the subsequent treatment of the film is incorrect the diagnostic value of the radiographic record is proportionally impaired.

However the dark-room technic is more mechanical in character, is not subject to the great variations, and requires less skill and judgment than the operative technic. This portion of the work may be entrusted to a careful, conscientious assistant, but the radiodontist should be a master of all the details of the procedure to properly train assistants and maintain the requisite standard of production. Since the treatment of the films after exposure is a chemical process, all steps should be performed with accuracy and freedom from contamination. It is easier to be habitually careful than to locate a cause of imperfect negatives and replace them with improved ones.

Facilities.—The first essential for the convenient and correct development of films is a suitable room. Makeshifts such as developing cabinets and clothes closets are not conducive to efficient results, or the routine use of radiography. The space and facilities should be proportionate to the volume of radiography, but some requirements are imperative. Light must be excluded, the illumination must be safe for the manipulation of radio-

graphic films, and the ventilation must be adequate. Running water, refrigeration, work shelves, storage cabinets, and provision for entrance and exit without admitting light are indispensable for convenience. To test the safety of a dark-room lamp, place a coin on a film of the most sensitive emulsion used, and lay them slightly closer to the lamp than the films are held for manipulation and inspection. After this exposure to the colored light for five minutes develop and fix the film. If any fog is visible around the area covered by the coin, the illumination is unsuitable. To correct the fault, place additional red paper on the window of the lamp or replace the electric bulb with one of less intensity, and if there are any cracks from which white light escapes cover them with black adhesive tape. The test should be repeated until the illumination is safe.

Developing Methods.—The development of the image as the first step in obtaining a permanent record of the examination offers a greater variance in methods than any of the subsequent procedures. The time and temperature method is generally recommended, and there are some advocates of the factorial method, but the inspection method is used and advised by the writer as a practical means of producing uniform, diagnostic negatives.

The time and temperature method is the development of all films the normal time for the existing temperature of the solution. Although this is theoretically correct, it is impracticable in application because of the difficulty in accurately judging the penetration and calculating the exposure required. Correct exposure in intraoral examinations may vary 50 per cent for different subjects, and 100 per cent for different regions of the same subject. Since there is no precise means of determining this variation in advance, one or more test exposures of each region would be required to obtain the desired uniformity

in negatives. The weight and age of the subject, and the thickness of the alveolar process are less important factors in calculating exposure than the type of bone, which cannot be determined without a radiability test.

The factorial method is the computation of the normal development time by multiplying the time required for

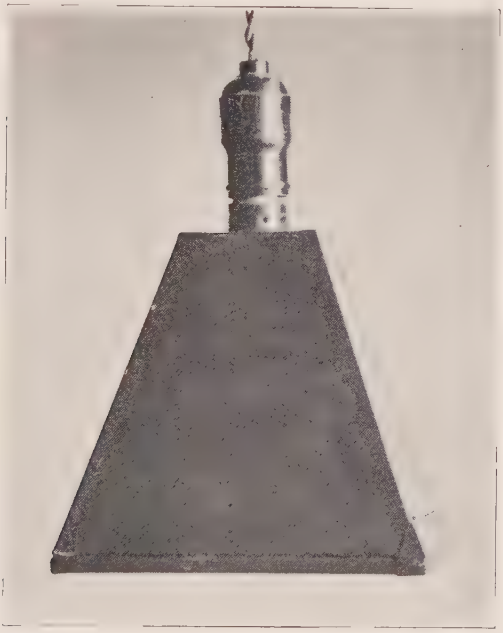


Fig. 145.—A dark-room lamp which directs the red light downward and is suitable for development by inspection.

the first appearance of the image by the numerical factor of the developing agent used. For example, the numerical factor of hydroquinone is 5, so if the image appeared in 55 seconds the development would be complete in $5 \times 55 = 275$ seconds or 4 minutes and 35 seconds. This is sound chemistry but a foolish application, because it requires almost constant inspection of the films in the early stage of development when they should be sub-

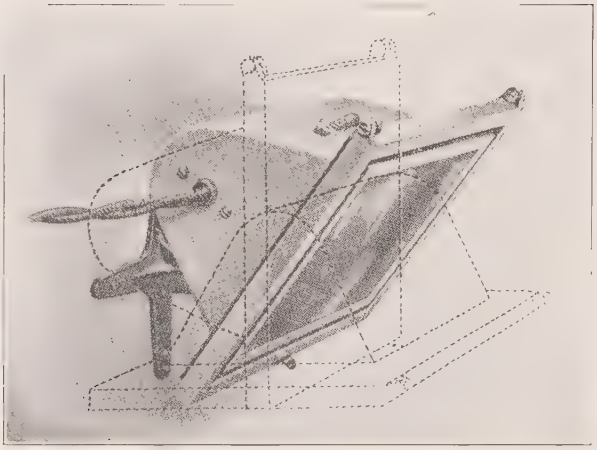


Fig. 146.—A dark-room lamp from which the red light may be directed in different directions.

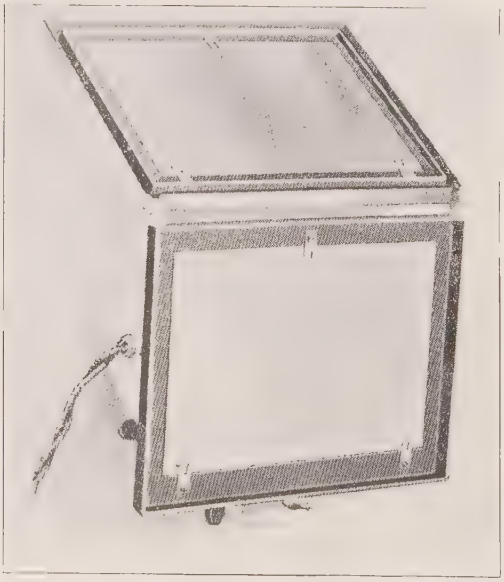


Fig. 147.—The lamp shown in Fig. 146 opened as an illuminator with diffused white light.

merged in the solution, and a mental registry and calculation of the development which becomes more intricate with the number of films in the developing solution. This method has long been discarded by photographers, and has little practical value except for experimental purposes.

Development by Inspection.—The inspection method offers the opportunity of improving underexposed negatives and correcting overexposed negatives in the course of development. To apply the method to intraoral films they should be attached to separate holders instead of grouped on a holder, and inspected by reflected light on the nonemulsion side during the latter stages of development. The films should be submerged in the developer and vigorously shaken to remove air bubbles, with an occasional movement to circulate the solution left until about two-thirds of the normal development time has expired, then held with emulsion side down under a red light to observe the shade. A little experience will enable one to judge the speed of development and one or two additional inspections should suffice to stop the development when the desired density is reached. The periods of inspection should be as brief as possible so the absence of the films from the solution will not be prolonged.

In radiography, as in photography, the safe exposure rule is to "expose for the shadows" or give ample exposure. To insure uniform radiographic negatives the exposure and penetration should be slightly in excess of the preliminary calculation, for which compensation if necessary may be made by reduction in the time of development. Contrary to the emphatic statements of professed authorities, radiographic negatives may be given an excess exposure of 25 per cent and the development correspondingly decreased without loss of diagnostic quality. When operating with the principle of ample

exposure and the inspection method of development there are rarely additional exposures required because of incorrect exposure. If the exposure should be slightly deficient it may be "forced" within a safe limit to increase the density, and if excessive the development can be stopped at the desired density.

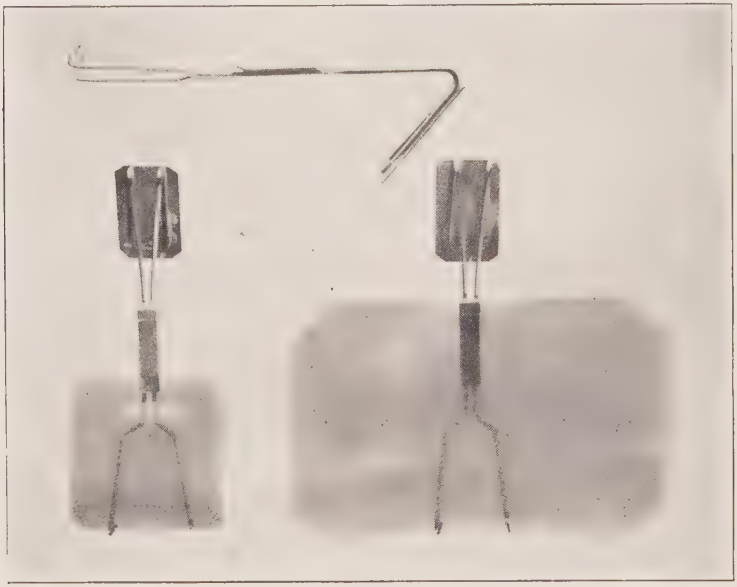


Fig. 148.—Developing holders suitable for individual development. They do not mar the films, but protect the emulsion side which is turned toward the holders and the films are easily attached and removed.

This system is not intended to encourage careless excessively long exposures, but to correct the results of unavoidable miscalculation. Constant effort should be applied to accurately calculate exposure, but since no one has demonstrated that this can be done, a practical method of dealing with the exposure problem is gratifying. When the films are being developed as the examination proceeds, the subsequent exposures and penetration can be gauged by the report of the dark-room assistant

on the development time and the appearance of the first two or three films. Other writers on this subject have implied that the radiographer or the assistant was not sufficiently expert to employ the inspection method, but the average assistant can be trained within three days to produce reasonably uniform negatives. If after a few days' training an assistant does not demonstrate satisfactory progress, she probably is deficient in shade perception and unfitted for service in a radiographic practice.

Special emphasis is indicated regarding the temperature of the developing solution. Since 65 degrees is the temperature at which developing agents function most efficiently, the solution should not be used below 64 degrees or above 67 degrees. The temperature should be stabilized at 65 degrees before development is begun, and means such as a water-bath for the developer container, provided to maintain this temperature during prolonged use. An accurate dairy thermometer which floats and may easily be read should be conveniently placed and conscientiously used.

Density of Negatives.—The reference to the desired density suggests a discussion of the suitable density for radiographic negatives. In the earlier period of oral radiography, the customary directions for viewing intraoral films was by strong transmitted light. This was necessary to view the extremely dense negatives which were produced, and the effect of this custom is still evident. Negatives so dense as to require strong transmitted illumination are lacking in contrast because, the detail is obscured in the highlights, the shadows are fogged by scattered radiation, and consequently the halftones are almost obliterated. While in the attempt to make all negatives dense, doubtless many were impaired by chemical fog from forced development. In the absence of a published standard of negative density, it

may be described as that in which the detail of the entire image is revealed by the light reflected from unglazed white paper nine inches from a shaded 100 watt lamp. Negatives of this density may be satisfactorily viewed toward the sky or suitable illuminators, but are not dense enough to view toward the sun or undiffused artificial light.

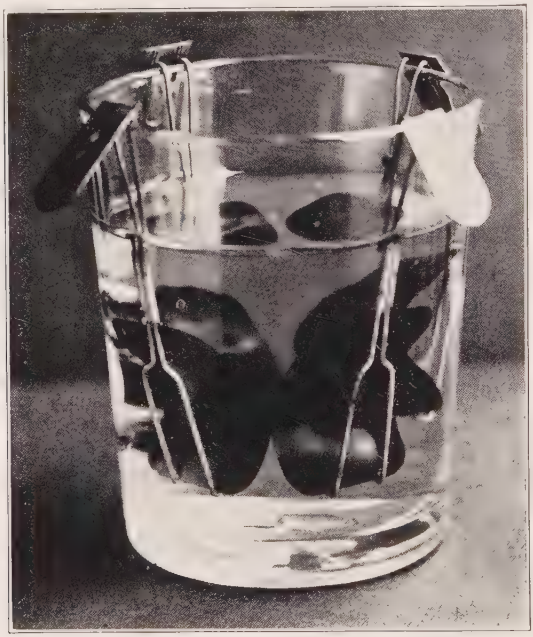


Fig. 149.—A convenient container for rapid developing solution, accommodating two pairs of films in 6 ounces of solution. This capacity will develop the films as rapidly as they can be manipulated.

Developing Formulae.—The following developer formula is a modification of one obtained from Dr. R. Ottolengui. The rapid action of this solution is a great advantage when films are developed individually and during the course of the examination. It gives the maximum contrast and detail, with a delightful quality for radiographic negatives. The disadvantages of the

solution are the rather rapid oxidation when exposed to the air, and the caustic property which contraindicates contact with the skin. The oxidation may be controlled by covering it with a float or transferring it to a stoppered bottle of the exact capacity, and the caustic action from unavoidable contact may be neutralized with the acetic acid bath.

DEVELOPING FORMULA FOR INTRAORAL FILMS

STOCK SOLUTION

Distilled Water	50 oz.
Potassium Hydroxide	8 oz.
Sodium Sulphite	8 oz.
Potassium Bromide	1 oz.

DEVELOPING SOLUTION

Water	4 oz.
Elon	20 gr.
Hydroquinone	40 gr.
Dissolve and add	
Stock Solution	2 oz.

Normal development time is 90 seconds at 65° F. This six ounce quantity is sufficient to develop sixty pairs of No. 1 dental films, but should not be used after the oxidation from the air has changed it to a coffee color. The elon and hydroquinone may be weighed in advance and retained in No. 11 veterinary capsules ready for use. Avoirdupois weight is used in compounding photographic formulae.

When the development has reached the desired stage the films should be quickly rinsed in water, and placed in a neutralizing and hardening bath for 30 to 60 seconds.

NEUTRALIZING AND HARDENING FORMULA

Water (warm)	50 oz.
Chrome Alum	20 oz.
Acetic Acid (28%)	20 oz.
Water to make	128 oz.

(In cool weather and climates the strength of this solution may be reduced 50 per cent.) Six sounces of this solution may be used in a glass, and should be replaced by a fresh supply after acting upon sixty pairs of No. 1 films.

Then place the films in the fixing solution.

DEVELOPING FORMULA FOR EXTRAORAL FILMS

Distilled Water (warm)	50 oz.
Elon	150 gr.
Sodium Sulphite	14 oz.
Hydroquinone	550 gr.
Sodium Carbonate	7 oz.
Potassium Bromide	350 gr.
Distilled water to make	128 oz.

Normal development time is 5 minutes at 65° F. The films should be placed in the neutralizing and hardening bath for 30 to 60 seconds and then removed to the fixing bath.

Tank and Tray Methods.—Probably better negatives will be produced by the tray method of developing extraoral films, unless the volume of work demands the greater capacity of a tank. The advantages of the tray method are individual development, the use of a small quantity of fresh developing solution easily brought to the correct temperature, the opportunity of keeping the solution in motion by gently rocking the tray, and the facility of observing the progress of development except in the final stages without removing the film from the solution. In tray development the films should be submerged in water and turned before being placed in the developing solution to moisten the surfaces and promote an even application of the developer. During the process of development the tray should be gently rocked in different directions and the film quickly turned over about once a minute so the action of the solution will be uniform.

The disciples of the tank method will vociferously contend that all this can be more easily accomplished in a tank. So it could excepting the inspection, but it is rarely done. When a large quantity of developing solution is put in tank service, it is generally used until exhausted and it progressively deteriorates after the first day's use. There is difficulty and delay in bringing a large quantity

of solution to the correct temperature, and consequently a temptation to laxity in thermal requirements. When several films are being developed, the manipulation of them before and after development interferes with the constant agitation of the solution which is indicated for efficient action. The tank method is necessary for quantity production, but quantity production is often accomplished at the sacrifice of quality.

Fixation.—After development, the next step in securing a permanent record is the fixation of the image. There has been no choice in this process excepting a slight variation in the formulae regarding the acidifying and hardening agents. Sodium thiosulphate, commonly called hypo, is universally used to dissolve the undeveloped silver bromide from the negative, and this is the essential ingredient of the fixing solution. An acid to neutralize any alkali carried from the developer, a hardening agent, and a preservative are usually included in the formulae. The following formula has all the desirable properties with the great improvement of fixing films in half the time of the ordinary solutions. Obtaining the maximum hardening of the emulsion during fixation would dispense with the necessity for a separate hardening bath, but this is possible only by treatment before fixation.

RAPID FIXING FORMULA

SOLUTION A

Water (warm)	96 oz.
Hypo	32 oz.
Sodium Sulphite	2 oz.
Ammonium Chloride	6 oz.

SOLUTION B

Water	32 oz.
Chrome Alum	1 oz.
Sulphuric Acid	1 dr.

(If the neutralizing and hardening bath is not used, two drams of sulphuric acid is required.)

Add the sulphuric acid slowly. When both solutions are cool, slowly add solution B to A while vigorously

stirring the latter. Any fixing bath should be thoroughly agitated before use as there is a tendency for the hypo to settle in the solution. Films should remain in the fixing solution fully twice as long as required for them to clear, or about ten minutes for radiographic films. The thermal requirements of the fixing solution are not so exacting as those of the developer, but the temperature should be between 55 and 70 degrees.

A given quantity of this fixing solution is effective for twice the service of an equal quantity of developing solution, but should be discarded before there is a marked slowing of its action. The clearing of the emulsion is not proof of the efficiency of a fixing solution, and the excessive use of the bath will result in the subsequent discoloration of the negatives. The lights may be turned on when the films have been placed in the fixing solution without waiting for the emulsion to clear.

Washing Films.—After the negatives have been fixed, it is necessary to thoroughly wash the films to remove the chemicals of the fixing solution. Although the washing is imperative for the permanency of the negatives, it is a simple process with thoroughness as the only requirement. Within reasonable bounds, the temperature of the wash water is unimportant, but it should not be warm enough to injure the emulsion. With the hardening bath previously recommended, dental films of the regular emulsion may be successfully washed at a temperature of 90 degrees and double coated films will bear a temperature of 85 degrees. This temperature possibility is stated for the benefit of those who have not been able to use running water for washing in hot weather, but water at a lower temperature is preferable when it is available.

With water entering the bottom and flowing from the top of the receptacle, films are thoroughly washed in twenty minutes, and this method should be employed

where facilities permit. A special washing tank is not required, as a rubber tube from the water faucet may be inserted to the bottom of a pan or tank, and a multiple connection makes it possible to separate films in different stages of washing.

When running water is not available for washing, the films should be transferred into at least six changes of clear water, leaving them in each for five or ten minutes for a total time of forty-five minutes. After removing films from the wash water, they should be held emulsion side upward under a stream of running water to remove any foreign particles which may have adhered to the emulsion.

Reducing the Density of Negatives.—On account of the variance in thickness and radiability, in each region of an intraoral examination there is a sufficient difference in density in portions of the negatives to impair the diagnostic quality. Depending upon the general density of the negatives, portions will be either of excessive or deficient density to clearly reveal the detail of the structures. This is especially noticeable in the radiolucence of the maxillary sinuses, and where the nose or the malar process is superimposed on the teeth. Unless supplemental exposures are made in each region to produce negatives of different density, or local reduction is employed, the maximum information will not be obtained from the examination.

The logical solution of the problem is the application of ample penetration and exposure to record the thicker portions of the region in the negative, and then reduce the density of the negative where the radiographic action has been excessive. There are characteristic areas in each region which require local reduction, while edentulous areas with the adjacent teeth included in the negative, and unusual formation require special reduction

Fig. 150-*A*

Fig. 150-*B*.

Fig. 150.—A typical maxillary incisor region before and after local reduction of the negative.

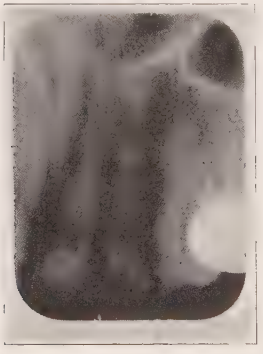


Fig. 151-*A*

Fig. 151-*B*

Fig. 151.—A typical diagonal view of the maxillary incisor region before and after local reduction of the negative.

Fig. 152.-*A*.

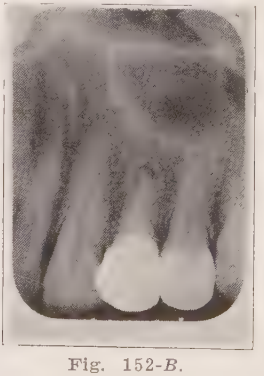


Fig. 152-*B*.

Fig. 152.—A typical maxillary cuspid region before and after local reduction of the negative.

treatment. Equalization of density should not be attempted, but merely the reduction of the denser areas to a shade in which the structural detail is disclosed by the customary illumination. This process does not efface the radiographic evidence of pathologic conditions, but instead reveals minute structural alterations which otherwise would be obscured. When a cutting, rather than a proportional or flattening reducing agent is used, the contrasts of the image are accentuated which to the point of losing detail in the shadows is advantageous. After some experience, the local reduction of intraoral negatives can be quickly accomplished, and the evident improvement will compensate for the additional labor.

Reduction Technic.—After the films have been removed from the fixing solution and washed for five minutes or longer, place the receptacle convenient to a favorable illumination and seat, so the reduction may be done in comfort. A granite-ware pan sixteen inches square, in which the receptacles may be placed, is an aid in confining the solution and water dropped during the operation. The reducing solution should be mixed in a small dish, and applied with a pledget of cotton tightly rolled on a wood applicator. If the general density of the negative should be too great, the film should be submerged in the solution for periods of one to five seconds to obtain the desired density of the shadows before the reduction of the highlights is begun. To stop the action of the reducer, dip the film in water. The action may be increased by adding more of solution B.

For local reduction, the film, emulsion side upward, should be held so the solution will flow toward an area requiring the action instead of one which does not. This may often be regulated by curving the film to produce a concavity at the desired location, by pressure of the thumb and finger on opposite edges of the film which

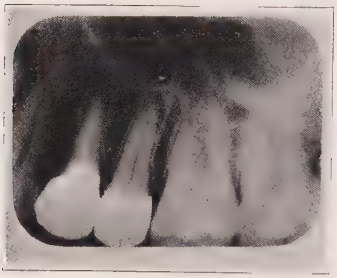


Fig. 153-*A*.

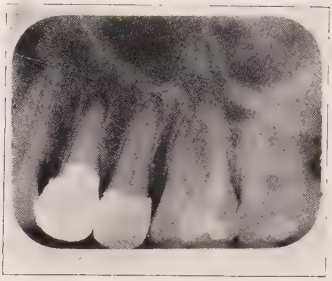


Fig. 153-*B*.

Fig. 153.—A typical maxillary first molar region before and after local reduction of the negative.

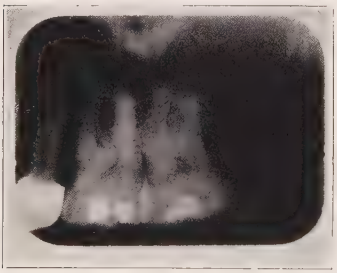


Fig. 154-*A*.

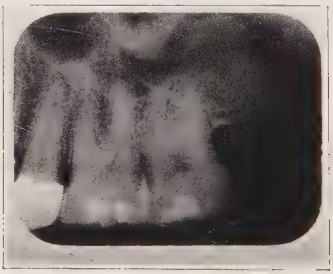


Fig. 154-*B*.

Fig. 154.—A typical maxillary second molar region before and after local reduction of the negative.

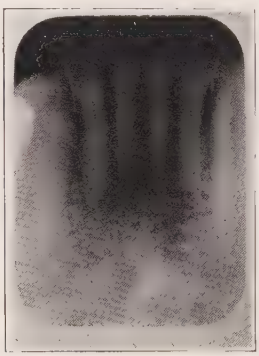


Fig. 155-*A*.

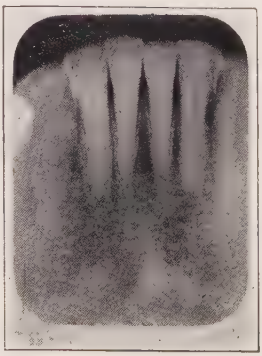


Fig. 155-*B*.

Fig. 155.—A typical mandibular incisor region before and after local reduction of the negative.

Fig. 156-*A*.

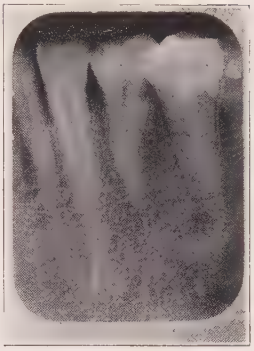


Fig. 156-*B*.

Fig. 156.—A typical mandibular cuspid region before and after local reduction of the negative.

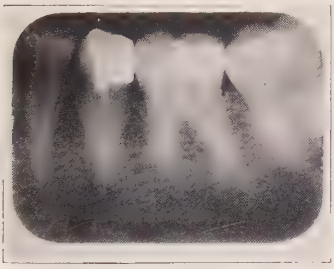


Fig. 157-*A*.

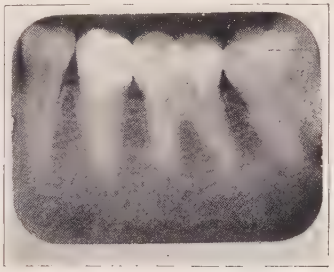


Fig. 157-*B*.

Fig. 157.—A typical mandibular first molar region before and after local reduction of the negative.

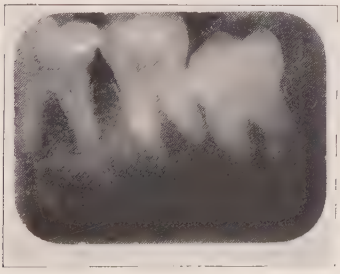


Fig. 158-*A*.

Fig. 158-*B*.

Fig. 158.—A typical mandibular second molar region before and after local reduction of the negative.

should be the method of holding to avoid softening the emulsion. After reduction, five minutes' washing in running water is ample to remove the reducing solution, but the total washing time before and after reduction must be at least twenty minutes to remove the hypo.

FORMULA FOR REDUCING SOLUTION

STOCK SOLUTION A.

Water	16 oz.
Sodium Cyanide	65 gr.

STOCK SOLUTION B.

Water	1 oz.
Potassium Iodide	80 gr.
Metallic Iodine	40 gr.

REDUCING SOLUTION

Solution A	1 oz.
Solution B	20 mm.

Fig. 159-*A*.

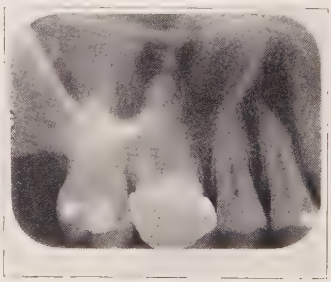


Fig. 159-*B*.

Fig. 159.—A maxillary first molar region in which the pathologic involvement of the bone is obscured in the negative until disclosed by local reduction.

The reducing solution should be freshly mixed for use, and as the action slows a few drops of solution B should be added. Extreme care must be exercised in handling the solution, as sodium cyanide is highly poisonous by absorption in the mouth and to a lesser degree by inhalation. The solution does not affect the skin unless there is a susceptibility to iodine, and it may be used without harm if not directly inhaled or carried to the mouth. However, caution is indicated in handling smok-

ing articles when using the solution, and subsequent washing of the hands and utensils.

This formula is recommended instead of those generally used because of its rapid action, cutting characteristics, and negligible staining properties. The conditions under which staining has been observed were when the emulsion had dried before the hypo was completely eliminated, and after the use of a proprietary fixing solution the secret of which is more scrupulously maintained than is the excellence of the product. A small avoirdupois scale which may be purchased from a photographic supply dealer is a convenient and economic accessory to the dark-room equipment since it relieves one from dependence upon and tribute for prepared compounds.

Increasing the Density of Negatives.—Negatives lacking in density from underexposure, underdevelopment or both may be materially improved by chemical treatment. This process is not generally utilized in radiography because with most methods considerable time is required, the results are uncertain, and the tone of the negative is altered. If the error in exposure or development is discovered during the examination another exposure is preferable to intensifying the negative, but with the following formula the process is simplified and some of the objections are avoided. After the negative is fixed and washed it is placed in the intensifying solution for a few seconds to a minute depending upon the amount of intensification desired. After washing to remove the excess solution it is placed in slow developing solution for three minutes to clear and fix the image, and a few minutes' washing in running water completes the operation. A small quantity of developing solution should be used for this purpose and discarded.

FORMULA FOR INTENSIFYING SOLUTION

Water	16 oz.
Potassium Iodide	80 gr.
Mercuric Iodide	80 gr.
Hypo	5 gr.

It requires about 24 hours for the mercuric iodide to dissolve, unless the bottle is placed in a hot bath and occasionally shaken.

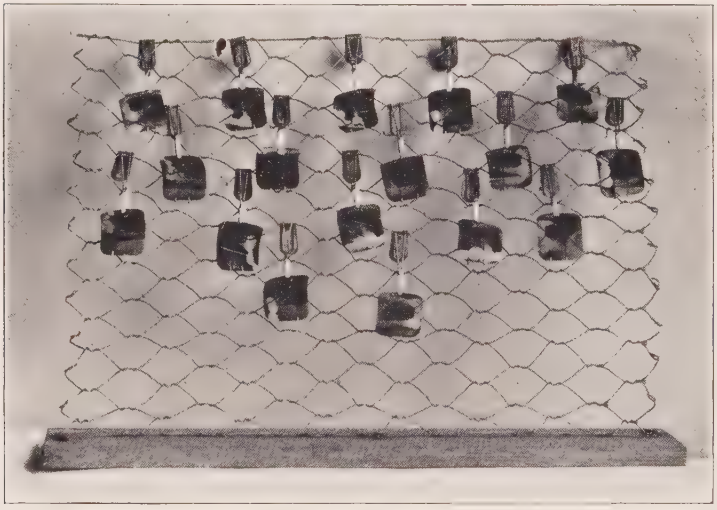


Fig. 160.—A drying rack made by attaching wire netting with staples to a wood base. With this arrangement the films of each examination can be kept separate and carried from place to place.

Drying Films.—The films should be shaken to remove all the water possible and hung in a place free from dust where there is a current of air at a comfortable room temperature. The drying may be hastened by directing the air from an electric fan on the nonemulsion side of single-coated films and the edges of double-coated films, but the fan and shelf should be free from dust. Probably the ideal arrangement for drying films is a dust-proof cabinet in which is installed a dryer such as used by hairdressers to produce a current of warm air. By keep-

ing the films of each examination separate throughout the various processes, a labeled film hook is sufficient identification for each group without mutilating the negatives by distinguishing marks.

Mounting and Filing Negatives.—Reasonable care must be given to the manipulation and disposal of negatives after drying, to keep them undamaged and accessible. When films are removed from the drying rack they should be placed in a filing envelope on which the essential data has been written, and the envelope deposited in a temporary file until time for a final disposition. Usually one set of intraoral negatives should be mounted for convenient viewing, and the duplicates filed in an indexed cabinet. In the case of referred patients, it is customary to send the mounted negatives to the referring dentist or physician, and when a consultation is in prospect or the negatives are to be viewed for operative purposes the mounted arrangement is advantageous.

In mounting a group of intraoral films, they should be paired and laid in regional order on a clean surface, preferably white paper. Then each pair should be viewed to select the more suitable density for uniformity, and when there are different views of a region these should be compared to decide which may be eliminated from the mounted group. After the films to be mounted are selected, they in turn should be firmly held on a clean flat surface while the nonemulsion side is polished with a soft cloth to remove the water spots. To this stage the films should be handled by the thumb and finger on opposite edges, but in mounting them the finger covered by a soft cloth should be placed on the emulsion surface while the thumb reciprocates on the opposite side. This precaution avoids finger marks on the emulsion which mar the appearance and perhaps the utility of the negatives. The negatives should be mounted to view from

the nonemulsion side, because this is the aspect of the structures recorded when the emulsion side of the film is presented toward the tube. Aerial perspective is not only evident in radiographic negatives, but is exaggerated by scattered radiation. For example, an unerupted tooth lying on the lingual side of the other teeth will register in an intraoral negative as denser and sharper in outline than the other teeth, and appear nearer the observer than

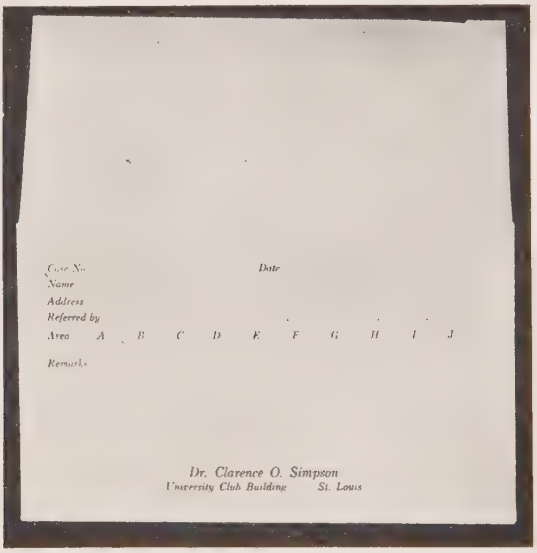


Fig. 161.—An illustration of a filing envelope 3x5 inches on which the line spacing conforms to that of a typewriter for convenience in typing the data. The form of the flap is convenient for filing.

the other teeth. Therefore when the negative is viewed from the nonemulsion side with a subconscious impression of the relative location of film, teeth, and tube, the unerupted tooth correctly appears on the lingual side of the other teeth. Conversely, when the negative is viewed from the emulsion side with the idea of observing the structures from the facial aspect, the unerupted tooth still appears nearer the observer and lying on the facial

side of the other teeth, which is incorrect. Even when linear perspective is recorded by stereoscopic examination, the illusion is more distinct when viewed from the nonemulsion side because of the intensified aerial perspective.

Mounts for intraoral negatives should be of the type having unobstructed openings for viewing. Neither a translucent base for the negative, nor a diffusing material back of the film is indicated with suitable illumination, and a translucent medium in the approximate plane of the image is distracting to the vision. Translucent celluloid back of the film lowers the tone and obscures the detail in negatives, while the protective feature is counteracted by the abrasion of the contact surfaces. Radiographic negatives cannot be protected from damage by people who are careless and unappreciative of them. The person who holds unprotected negatives by placing a perspiring finger on the emulsion will scratch the films by sliding them on the protective celluloid and probably extract the negatives to hold them with perspiring fingers, or break the glass if negatives are bound between glass plates. The safety match was invented to protect furniture, walls, and trousers from the type which mar radiographic negatives, and moisten the thumb with saliva to turn pages, so this sustains hope that inventive genius will devise adequate protection for unvarnished negatives.

Prints and Transparencies.—Anyone who extensively practices oral radiography will need reproductions to illustrate articles for publication, and on glass for stereopticon projection. Photographic finishers and dealers in stereopticons can supply these copies, but the quality of the product is usually mediocre and the specimens commonly exhibited illustrate little except poor craftmanship. If one is discriminating and sufficiently desirous

of superior illustrations, the process can be mastered to an economic and technical advantage. A printing frame is the only additional accessory required, although a small automatic printer is more convenient.

For prints on paper the negatives are placed emulsion side upward on the glass of the open printing frame, the paper placed emulsion side down on the negatives, and the exposure made. A few test exposures will enable one

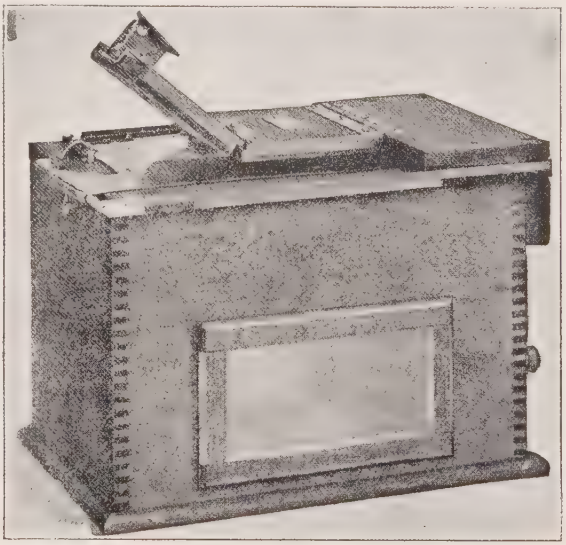


Fig. 162.—The small automatic printer for making prints and transparencies.

to closely calculate the exposure for negatives of different density and different grades of paper. With a supply of paper for various degrees of contrast, the results can be effectively controlled. The greatest detail is obtained with glossy paper, and by drying the prints on a ferrotype plate. Extraoral negatives and mounted groups are copied by photographing to a reduced size and printing from the photographic negative.

Stereopticon reproductions are made on lantern slide

plates which may be purchased from dealers in photographic supplies. The printing process is the same as for paper except the exposure is greatly reduced. When a 10 watt lamp is used for printing, the printing frame should be placed about six feet away so the exposure can be accurately timed and corrected. In using an automatic printer for lantern slide plates, the clear and red lamps should be covered with sufficient white paper to reduce the illumination to a suitable intensity. The exposure should be limited to a degree which will permit normal development to produce a dense black mat around the negatives. After the lantern slide plates have dried a cover glass is bound on the emulsion side with binding strips made for this purpose. A marker on the lower left corner of the cover glass directs the placement of the slide in the lantern. The cover glass may be obtained by removing the emulsion from unsatisfactory plates.

FORMULA FOR REMOVING EMULSION

SOLUTION A

Water	4 oz.
Sodium Fluoride	30 gr.

SOLUTION B

Water	4 oz.
Sulphuric Acid	30 mm.

Place the plates in solution A for two minutes, and then in solution B for two minutes, and the emulsion can readily be removed.

If reproductions are desired as negatives instead of positives, a print may be made on "commercial" film and this image transferred to the paper or transparency. The local reduction of radiographs, to modify the contrast of the denser portions, aids in obtaining true reproductions.

CHAPTER X

DANGERS AND PROTECTION

In the decade following the discovery of x-rays there was a gruesome harvest of burns resulting from indiscriminate and unrestricted exposure to the radiation. The responsibility for this may be placed on the physicists of that period, especially Professor Roentgen who discovered the rays but was inconceivably negligent in not fully testing their physical properties. A few simple experiments on animals would have served as a precious warning of the injurious action of the rays. The crude apparatus was a contributory factor in many serious burns, since without means to determine the quality of the rays the operator's hand was used as a penetrometer and with inefficient tubes, subjects were often exposed to dangerously soft rays.

With modern radiographic equipment it is generally believed and stated that there is no danger incident to its use, but on the contrary the danger is greater than ever before because of the more powerful apparatus. Comparative safety is secured only by restricting exposure to safe limits, utilizing the protective measures indicated, and employing constant vigilance in operating. Safety rests upon the knowledge and care of the operator, and not in any type of apparatus which generates x-rays.

Electric Shock.—The principal dangers in the operation of radiographic equipment are of two kinds, electric shock or burn from the high voltage current and exposure to radiation. From time to time a death occurs from shock by x-ray apparatus, although the current used for radiography which rarely exceeds 70000 volts or 30 milli-

amperes is not inherently a fatal current. Age (either the very young or elderly), organic disease, reduced vitality, favorable conducting conditions, prolonged contact and the route of the current through the body contribute to serious results from electric shock. Since these factors cannot be controlled, rigid precautions must be maintained to avoid accidental shock.

The operating chair should not be "grounded" either intentionally as is sometimes done, or unintentionally by the attachment of a fountain cuspidor or contact with heating, gas, or water pipes. All high voltage wires and connections should be kept a distance of twice the back-up from the patient and other persons present, and the high voltage switch should not be closed without the path of the current being under the observation of the operator. A foot switch increases the risk of shock through the possibility of someone thoughtlessly or accidentally stepping upon it. An automatic circuit breaker reduces the danger of serious shock, but should not be depended upon as a substitute for other precautions.

Overhead installations should be amply secure to prevent any part falling while the current is passing through it. Tubular conductors supported by bracket insulators are much safer than wire aerials under tension. For protection of the operator all switches and controls should have insulated handles and be inclosed, and as a further precaution they should not be manipulated with damp hands or with both hands simultaneously. Crowded quarters and the proximity of other equipment favor accidents in the operation of radiographic apparatus, and if the space is available a room should be exclusively used for the examinations. The static which accumulates around high voltage apparatus is of no consequence except when contact with the tube stand causes the

patient to move during an exposure. This may be prevented by a ground wire or chain on the tube stand, but avoiding contact with the patient is the easier and preferable method.

X-Ray Burns.—The danger of injurious exposure to the radiation should be seriously considered in the operation of x-ray machines. This danger exists in excessive exposure of patients during examination, and in the cumulative effect of repeated exposure on the operator and associates. To guard against an erythema dose in the radiographic examination of a patient, one must know and never exceed the limit of safe exposure. Although there is considerable variance in the estimates of an erythema dose under the conditions prevailing in radiography, 1800 milliampere seconds with a 4½ inch back-up and an 18 inch target-film distance may be accepted as an average erythema dose. Since some subjects are more susceptible to radiation than others, it is inadvisable to apply more than two-thirds of the erythema dose or 1200 milliampere seconds.

In practical application no area of the face should receive more than 1200 milliampere seconds during an examination or within a period of two weeks, and the overlapping of adjacent regions must be considered in the calculation. With a cone three inches in diameter, two maxillary and two mandibular regions adjacent to each other will overlap in the area of their common juncture, so the total exposure of the four regions would be the skin dose in that location. The effect of exposure from the opposite side of the face is much reduced, and a total exposure of 3000 milliampere seconds may be distributed in a general radiodontic examination with an 18 inch target-film distance (target-skin distance ranging from 15 to 17 inches) and an average back-up of 4½ inches.

An important precaution before an extensive examination is to ascertain whether or not the patient has been recently exposed to radiation, and if so to what amount. This should be done without arousing fear, but is necessary because of the prevalence of inferior radiography which occasions repeated examinations. When there is a possibility of exceeding a safe limit of exposure, the examination should be deferred for two weeks.

The use of filters is a negligible factor compared to other precautions against harmful exposure in radiography. While a filter absorbs the softer rays, the exposure must be proportionally increased to compensate for it, and it may give a false impression of protection in exceeding a safe exposure. Atmosphere acts as a practical filter, hence increasing the distance of the tube from the patient reduces the danger of dermatitis. The proportion of soft rays decreases as the voltage is raised, but they are not entirely eliminated at a high voltage.

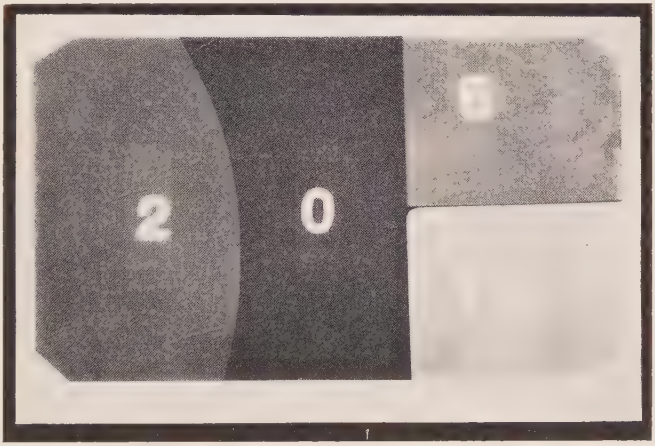


Fig. 163.—A test radiograph illustrating the relative effect of filters in radiography. In this exposure aluminum filters two-tenths, five-tenths, and ten-tenths of a millimeter in thickness corresponding to the numerals were laid on the film packet but the center was not covered. It will be observed that radiation sufficient to blacken a film is almost entirely absorbed by one millimeter of aluminum.

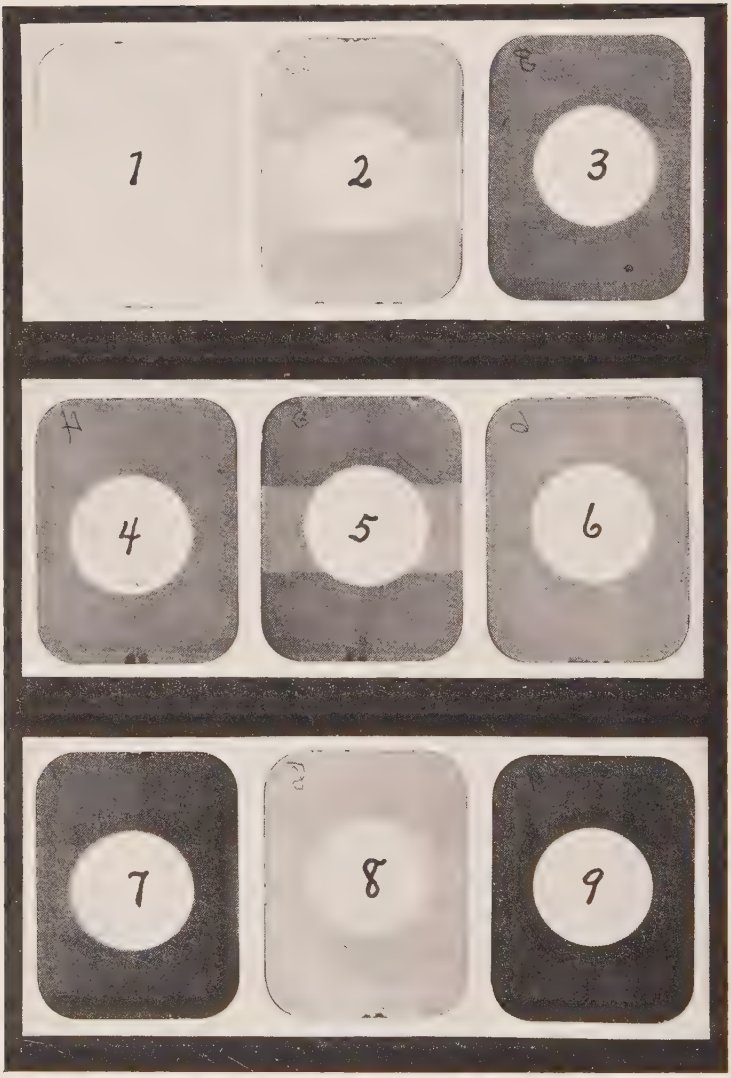


Fig. 164.—The results of experiments in secondary radiation, and penetration. The films marked 1 to 7 inclusive were protected from the primary rays by lead during a thirty-second exposure, a coin being attached to the face of each packet. Number 1 the control was exposed only to the scattered radiation from the air. Number 2 was exposed to the secondary rays from lead six inches distant. Number 3 was exposed to the secondary rays from wood six inches distant. Number 4 was exposed to the secondary rays from aluminum six inches distant. Number 5 was exposed to the secondary rays from iron six inches distant. Number 6 was exposed to the secondary rays from glass six inches distant. Number 7 was exposed to the secondary

With a 4½ inch spark gap, the exposure required for any intraoral radiograph needs no filtration for safety other than reasonable target-skin distance, and a filter will not protect from excessively prolonged or repeated exposure.

A thin filter is indicated to prevent the patient from looking at the lighted tube or feeling the heat from it, and to protect the patient from particles of glass if the tube should be broken. For this purpose $\frac{1}{10}$ of a millimeter of aluminum is sufficient, and a filter thicker than ½ of a millimeter is contraindicated in oral radiography because it would absorb radiation which is desirable for radiographic contrast.

Protection of Operator.—Rigid precautions are required for the protection of the operator and associates in the practice of radiography. The effect of repeated exposure is cumulative and insidious, so a procedure which insures ample protection should be established and maintained. With rare exceptions the film packets during exposure should not be retained by the operator or assistants. The cone should not be directed toward the operator or assistants when the tube is in operation. Wood or glass partitions offer no material resistance to the rays, so the cone should not be directed toward associates without the protection of a tile wall.

The tube should be inclosed in a lead glass shield because there is sufficient scattered radiation emitted from the back of a tube to disclose the bones of the hand through a fluoroscope. With the bowl type of shields, there is no protection from the uninclosed back or the notches for the stems of the tube. Through the opening

---

rays from a patient's face six inches distant. These tests demonstrate the importance of secondary radiation in radiography. Number 8 was exposed to the direct radiation from 45 kilovolts at a distance of 12 feet. Number 9 was exposed to the direct radiation from 72 kilovolts, at the same distance and for the same milliampere seconds as Number 8. This test demonstrates the effect of increasing the voltage with other factors remaining constant.

for the cathode stem, primary rays escape which will quickly fog films at a distance of ten feet.

The operator should stand at least six feet back of the tube in operation, and if an average of more than ten exposures per day are made the operator should stand behind a protective screen or wall. A lead lined screen or door six feet or more from the tube and preferably just inside an adjoining room is an effective protection, but if the operator reaches beyond it for the controls or habitually grasps the edge of the screen with the hand

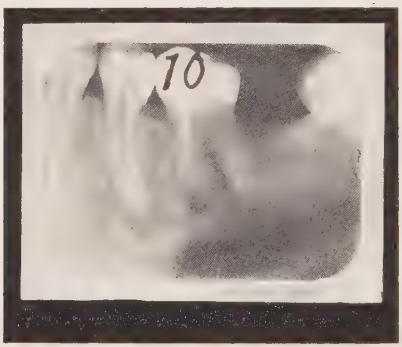


Fig. 165.—A test radiograph illustrating the inadequate protection of wood partitions and doors. In this exposure the bicuspid portion of the region was behind a wood door one and one-half inches in thickness. The practical application is that radiographs could be made through a wood door with less exposure than if a millimeter of aluminum was used as a filter, and that wood offers no protection.

these projecting parts are unprotected. This precaution applies even though the tube is inclosed in lead glass, because secondary radiation occurs from the patient and all objects in the path of the rays, especially metal equipment.

If there is doubt about the adequacy of protection, a test should be made by attaching a coin with adhesive tape to a film packet placed in the questionable location facing the tube. After a month of routine operating, if the outline of the coin is not disclosed on the developed

film the location is reasonably safe. If the controls are operated from behind a protective screen, the test packet should be placed back of the lead glass window as it is less radiopaque than the lead-lined screen, coincidental developments and imaginative effects of radiation lead many operators to suspect the x-rays of injury for which they are not responsible. For mental peace and physical welfare all avoidable risks should be excluded that oral radiography may have a record of consistent service unmarred by harm to patients or operators.

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